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Summarizing Weather and Climatic Data—A Guide for Wildland Managers

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RESEARCH SUMMARY

This publication is a guide to the summarization of available fire-weather and climatic data by wildland managers, particularly for use in fire-management planning. The publication also covers general needs of forestry research. Various elements are discussed in an outline corresponding to a suggested report format; the format covers both the annual regime and the fire season. Examples are given for presenting the summarized data, including averages and frequency distributions in tables obtained through available computer programs. Graphs that can condense much of the information are also shown. Methods for adjusting or extrapolating values from limited data bases are included in a final section.

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INTRODUCTION

Weather and climatic data have long been important in the management and protection of our Nation's forests, particularly in the process of fire suppression or control. Use of such information has broadened in recent years under the new concept of fire management (Fischer 1978). Practice of this concept, which recognizes the natural role of fire in wildland ecosystems, considers a variety of resource management objectives.

Weather and climatic data are thus helpful in the planning of prescribed fires—for example, in establishing seasonal limits—and in evaluating the effects of fires, prescribed or wild, on particular resources. These effects may be strongly influenced by the weather, relative to "normal," during the ensuing months or years. The data can provide a baseline (of average or most likely weather conditions), together with a record of past deviations. Other applications, besides those related to fire, include planning for insect control, tree planting, road or trail construction and maintenance, recreational activities, environmental assessment reports or impact statements, and assessment of water supply potential for irrigation.

The purpose of this publication is to aid managers of forest and rangeland resources in their use of the available climatic data.[1] Our scope provides also for general needs of related research.

Emphasis is on evaluating and describing the climate of a particular location or area. Methods are presented for summarizing and presenting the data in tables, graphs, and possibly maps, together with guidance for interpretations and extrapolations. A more extensive discussion of data treatment methods can be obtained from Conrad and Pollak (1962); Oliver (1973).

ACQUISITION AND PROCESSING OF DATA

Climatic Data Requirements; Sources

The elements included in a climatic summary or description will vary, depending on the intended use as well as availability of data. Similarly, the time scale or resolution will vary. Contributing data may be from one or more observing stations representing an area. Interpolations or extrapolations may be made for other locations.

Table 1 outlines the suggested elements or items for a climatic description. Letter symbols, referring to primary data sources, denote inclusion in the specified time frame. Fuel moisture and fire-danger indices, which may be of more ultimate interest in fire management, are not included in our scope.

Much of the data base for the fire or land manager's needs may be obtained from fire-weather observations. These observations include the afternoon temperature, relative humidity, wind, 24-hour precipitation amount and lightning occurrence, and also the 24-hour maximum and minimum temperatures at many stations.[2] Such data have been archived in AFFIRMS (Administrative and Forest Fire Information Retrieval and Management System) format on tapes at the National Fire Weather Data Library, Fort Collins, Colo. (Furman and Brink 1975). They are available through offices that have access to the USDA computer at the Fort Collins Computer Center. Records thus obtained date back to 1954 for some stations (in Idaho, Montana, and Washington); to 1960–65 or later for most. Fire-weather data for additional stations and years may be located on original or carbon-copy forms. For example, those for Forest Service Region 1 stations are on file through 1970 at the Northern Forest Fire Laboratory (NFFL), Missoula, Mont.

For further areal coverage and year-round climatic information, data published by the U.S. Weather Bureau and its successor agencies are available in many libraries or from the National Climatic Center, Federal Building, Asheville, NC 28801. The data are limited mostly to valley or relatively low-elevation locations.

Greatest detail may be obtained from monthly and annual "Climatological Data," State summaries. These include the network of "cooperative" stations, some of which are also fire-weather stations (located at ranger stations). Contents include daily precipitation and maximum and minimum temperatures at each station, plus evaporation data and soil temperatures at a few locations; monthly windspeed, relative humidity, and sunshine data were given for airport stations, before 1982. Also

[1]The term climatic data will include weather data—the daily observations that become the material for climatic statistics.

[2]The 24-hour maximum and minimum relative humidity may also be available, but these data, obtained from hygrothermographs, are subject to large errors. The errors may tend to cancel over a period of years.

Table 1.—Suggested elements and time scales in climatic summaries. Letter symbols refer to data sources described at end of table. Dotted line defines items (generally to left) pertaining to fire-management planning

Element	10-day (Fire season only)	Monthly (Fire season only)	Monthly (12 months)	Annual (12 months)
	Source of data			
Precipitation, amount	F	F	C	C, Sa
number of days	F	F,C	C	C
Snowfall, amount			C	C
Snow cover, duration (days)				
and depth		C	C	C
snowpack		S	S	
Runoff			G	G
Thunderstorms, number of days	F	F,Ce		Be,Ce
Temperature, mean (24-hour)			C	C
daily maximum	F	F	C	
daily minimum	F	F	C	
afternoon dry bulb	F	F		
Freezing temperature				
threshold dates				C
Relative humidity,				
afternoon	F	F	Ae,Ce	
nighttime and 24-hour		Ae,Ce,F	Ae,Ce	
Dewpoint, afternoon	F	F		
Wind, afternoon		F	Ce	
nighttime		Ce		
24-hour			Ae,Ce	
Sunshine, number of hours		Ae	Ae	Ae,Be
percent of maximum possible		Ae,Ce	Ae,Ce	
Solar radiation			Ae, CNe	
Evaporation; potential				
evapotranspiration			Ae,Ce,T	Ae,Ce,T

F Fire-weather observations.
C Various climatological data publications by National Oceanic and Atmospheric Administration (formerly U.S. Weather Bureau) for individual States or stations.
CN Publication as above, except in form of national summary; data discontinued after 1976.
A Climatic Atlas of the United States (Environmental Sciences Service Administration 1968).
B Baldwin (1973).
S Snow survey data, published in monthly Water Supply Outlook and in Summary of Snow Survey Measurements (updated every 5 years); available for 11 western States from USDA Soil Conservation Service (SCS), Portland, OR 97209, and for California from California Department of Water Resources, Sacramento.
G Water-supply bulletins published by U.S. Geological Survey, Reston, VA 22092; later information available from State offices.
a Annual precipitation may be estimated from April 1 snowpack water content using method and graphs of Farnes (1971).
e Data are from airport or widely spaced stations.
T Thornthwaite Associates (1964).

published are "Local Climatological Data" (mostly for airport stations) and "Climatological Data, National Summary." The years of data have been summarized in several "Climatographies of the United States" (U.S. Weather Bureau 1932–37, 1954–58, 1964–65; National Oceanic and Atmospheric Administration [NOAA] 1971). Precipitation data for remote high-elevation locations were published annually in "Storage Gage Precipitation Data for Western United States," discontinued in 1976.

Additional summaries or special field data may be available from other agencies or from universities; for example, Pacific Northwest River Basins Committee (PNWRBC) (1968). A broader-scale picture, in map form, is provided by Environmental Science Services Administration (ESSA) (1968). The data sources are described more thoroughly by ESSA (1969) and Haines (1977); also, for the Columbia Basin States, by Columbia Basin Inter-Agency Committee (1965).

A future store of 24-hour fire-weather data may be provided by recently established remote automatic weather stations (RAWS) (Warren and Vance 1981); these are now installed at about 100 locations in the western United States.

Treatment and Processing of Data

DATA QUALITY CONSIDERATIONS

Errors and Missing Data

Before the acquired data are treated further, they should, ideally, be checked for errors and missing values. Corrections and estimates can then be made. Details are given in the final section of this report. In a search at the Northern Forest Fire Laboratory, many large and noncompensating errors were found in the fire-weather tape for the Forest Service Region 1 stations. There were, for example, some spurious 0 or 1 percent relative humidity values and rainfall amounts 10 to 100 times too high or low. Such errors arose largely in the processing of the original data.

Homogeneity of Data; Station Selection

A complicating factor in the use of climatic data can be change in location or exposure during a station's period of record. This commonly occurs in the network of "cooperative" stations. Even within small distances and elevational differences, such change can significantly affect the climatic averages. A change in daily observation time can be equally disruptive (see final section). In statistical terminology, the data series is no longer "homogeneous," or a sample of a single population (Oliver 1973). The effect may not be serious if the averages are intended only as a general indicator of the seasonal patterns rather than present truth for a specific location. Nonhomogeneity, however, can cause incorrect assessment of a current month's departure from normal conditions. For this purpose, in the case of cooperative stations, it may be safer to use an index that averages the data from a number of stations in or near a particular area. The odds are that inconsistencies at the individual stations will tend to compensate.

In the use of fire-weather data, major changes in afternoon observation time should be known; the record of time-affected elements, such as temperature and relative humidity, split accordingly. The statistics can then be adjusted, as described in the final section, to be compatible with present-day application.

SUMMARIZATION OF DATA; NORMALS

Tables summarizing fire-weather data can be obtained by computer programs (Bradshaw 1981) that are available at the Fort Collins Computer Center. These programs are similar to those used for the examples in the appendix and written by Louis T. Egging and Toni D. Rudolph at the Northern Forest Fire Laboratory. Output includes average and extreme values, as well as frequencies of specific values of weather elements, singly and in combination. These frequencies, if based on enough years of record, may be regarded as probabilities of future occurrence.

The tabular information may be condensed into graphs. Examples shown in this guide were drawn manually, but future computer programing may do the job. Aside from their more vivid portrayal and possibly easier use, the graphs can, when smoothed, help overcome accidental irregularities in tables attempting small time-scale (10-day) resolution. Such irregularities can be expected particularly when the number of years of data is small. The use of smoothing is widely practiced in treating climatic data. Various methods or formulas are given, for example, by Conrad and Pollak (1962); Panofsky and Brier (1963). A balance is sought that reduces accidental irregularities in a data sample while not obscuring characteristics that may be real. The smoothing suggested in this guide is apparently less than that used by NOAA (1973b).

Outside the fire season and for additional stations, only the averages and extreme values may be readily obtainable. Frequency distributions are included in PNWRBC (1968). A most recent general climatography issued by NOAA (1982) lists the average monthly temperatures and precipitation for those stations with a record covering the 30 years, 1951–1980. By international convention, this span of 30 years is the current standard "normal" period; the normals are updated every 10 years. A previous publication (NOAA 1973a) listed the 1941–1970 normals.[3] U.S. Weather Bureau (1964–65) gave averages for shorter periods, as well as the normals then based on 1931–60. Averages for additional stations can be calculated using tabulations from "Climatological Data," State summaries.

Length of Record

As just mentioned, the standard normal period covers 30 years. This length tends to balance out fluctuations over shorter periods; stability of the averages (and frequency distributions) and comparability among stations are sought. A longer period of record is actually desirable for precipitation, which can show large decade-to-decade (besides year-to-year) variation (World Meteorological Organization 1967); example, figure 1. A 20-year data sample, however, particularly with smoothing, should generally be adequate for 10-day averages and frequency distributions of the fire-season temperature, relative humidity, and wind. We would advise against only a 10-year sample (see fig. 2). Lengths of record provided by the fire-weather tapes may possibly be extended to the desired number of years if older observation forms are obtainable. For monthly averages, 10 to 15 years should generally provide accuracy, relative to a 30-year period, within $\pm 1°$ or $2°$ F ($\pm 1°$ C) for temperature and ± 1 or 2 percent for relative humidity. (This is indicated from tabulations by the author of average maximum temperatures at stations in 24 States.)

Where possible, the same specific years should be represented at all stations included in a climatic summary. The averages from stations having short records can be adjusted with good approximation to a common period, such as 20 or 30 years. This adjustment uses the "difference" and "ratio" methods detailed in the final section.

[3]No details were given as to average daily maximum and minimum temperatures. These were shown for "first-order" (mostly airport) stations in NOAA (1973b).

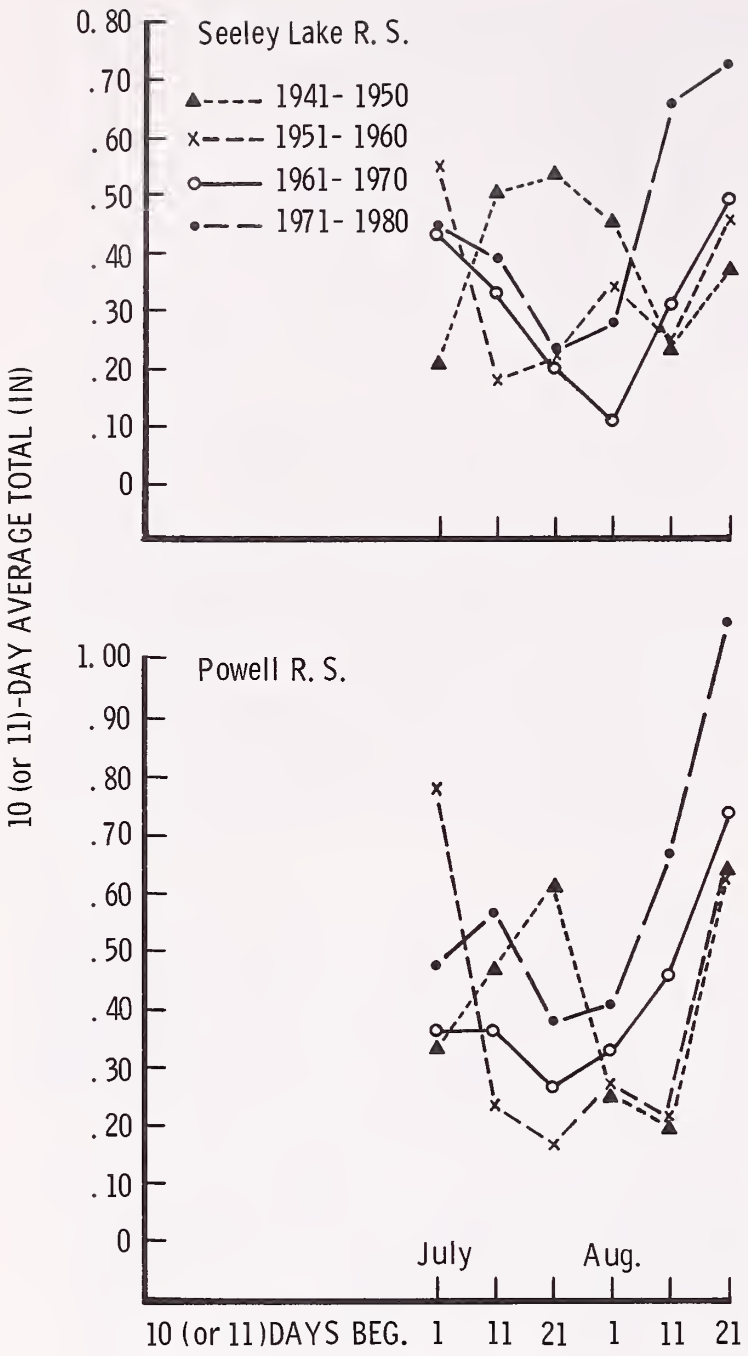


Figure 1.—Ten-day average rainfall during individual 10-year periods at Powell Ranger Station, Idaho, and Seeley Lake Ranger Station, Montana, July and August 1941–80.

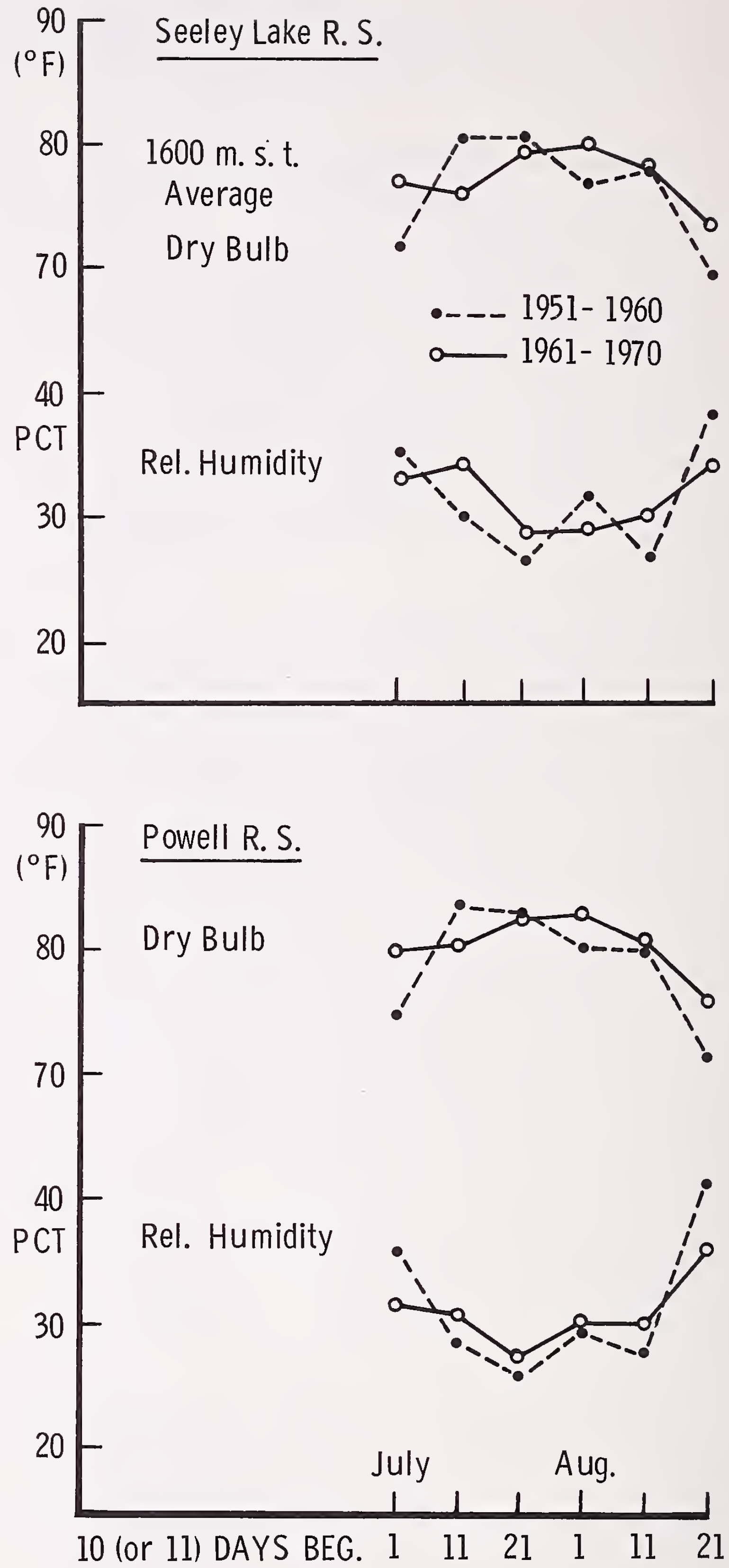


Figure 2.—Ten-day average dry bulb and relative humidity at 1500 P.s.t. (1600 m.s.t.) during two successive 10-year periods at Powell Ranger Station, Idaho, and Seeley Lake Ranger Station, Montana, July and August 1951–70.

PRESENTATION OF THE SUMMARIZED DATA; FORMAT

When the summarized data are presented in report form, the arrangement or sequence will vary, of course, with the individual perspective. A suggested format is given within the following outline of climatic items. Examples of this format can be found in Finklin (1983) and in an office report.[4] Examples of summary tables, graphs, and maps in this outline are mostly from these two references.

The suggested format begins with a general description of the area. Climatic information may be better interpreted if users can visualize the area's physical setting. A basic description is aided by a large-scale map showing the area's location and by a more detailed closeup map depicting the topography. Sufficient detail may be obtained from a map in the U.S. Army Topographic Command Series (fig. 3), available from the U.S. Geological Survey, Denver, CO 80225, or Reston, VA 22092. The user may also be aided by information as to: direction and straight-line distance from a familiar reference place, size and general shape of the area, terrain features including highest and lowest elevations and their locations, drainages, land ownership, habitat types, and general use.

Condensed Climatic Summary

This overview lends itself to use in management (and research) plans, including statements concerned with environmental assessment. The summary, in perhaps 500 words, condenses material from the climatic description that follows; it may actually be easier to write afterward. Suggested subheadings include Precipitation, Thunderstorms, Temperature, Humidity, and Wind.

Details of the Climate

In the present outline, climatic items are discussed first in terms of annual regimes—for example, monthly courses of average temperature and precipitation. The annual picture serves as a framework in which the fire-season climatic details can be presented. Our discussion pertaining to the fire season is given under a separate heading. In an actual report, for greater convenience to users, the annual regime and the fire-season climate may be described in separate main sections.

The fire-season climatic details are generally given with 10-day resolution. This season, that of the fire-weather observations, should include the main periods of wildfire occurrence and prescribed burning. The observation season at lookouts, however, tends to be much shorter than at ranger stations. In the Northern Rockies, for example, the observations are often limited to July and August at lookouts while extending 6 months (May through October) at many ranger stations. Methods of estimating details for the longer season, at least at other canyon or valley locations, are given in the final section of this report.

PRECIPITATION, ANNUAL REGIME

Units, inches or millimeters. Totals include rain and the water content of snowfall.

[4]Finklin, Arnold I. Climate of the Howard Creek area, Lolo National Forest, Montana. Missoula, MT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory; 1978, rev. 1981. Office report.

Average Annual Total

Besides the amount at one or more representative stations, the estimated range over the area may be given. If an areal precipitation map is presented (fig. 4), the averages should be based on or adjusted to a standard period, discussed earlier. Annual averages at snow survey courses may be estimated from the April 1 snowpack water content (Farnes 1971). When lines (isohyets) are drawn for mountainous regions, using the topography as a guide, at best only a generalized picture is possible. Although average precipitation generally increases with elevation, heavier amounts can be expected in the usually windward slope and canyon locations and lesser amounts in the lee ("rain-shadow") locations.

Extreme Annual Totals

These are the amounts that have been observed in the wettest and driest calendar years or water years (October through September); note the period of record.

Monthly Average Precipitation

When plotted, the monthly average amounts at a station are usually shown by a bar graph (fig. 5). These amounts and seasonal totals are often stated as percentages of the annual total. The wettest and driest months or seasons, together with secondary peaks, may be noted.

Monthly Frequencies of Days with Precipitation

These frequencies give the average number or percent of days (or 24-hour periods) with various amounts, such as $\geq$0.01 inch (0.25 mm), $\geq$0.10 inch (2.5 mm), and $\geq$0.50 inch (12.7 mm).

Snowfall, Annual and Monthly Averages

Units, inches or centimeters. These amounts refer to the summation of depths of individual daily snowfalls, before melting or settling occurs. The percentage contribution of annual snowfall to total precipitation may be estimated, using an appropriate average ratio of snowfall to its water content. An overall ratio of 12 to 1 (12.0 inches [30cm] of newly fallen snow containing 1.0 inch [25 mm] of water) appears reasonable for many parts of the United States, though much variation can be expected among individual storms (Landsberg 1958).

Snow Cover; Snowpack

Information on snow cover, at daily observation stations, may include the average monthly and seasonal numbers of days with 1 inch or more of snow on the ground; also the maximum depths. Snowpack, at snow survey courses, refers to the average depth and water content on the scheduled monthly survey dates, or at least on a peak-season date such as April 1.

Runoff; Relation to Precipitation

In a climatic context, average annual stream discharge, or "runoff," is expressed in equivalent depth. This depth, in inches or millimeters, is derived from the runoff volume, reported in acre-feet or hectare-meters, divided by the size (acres or hectares) of the drainage area. The stream should have little diversion or reservoir storage; otherwise the published runoff data should adjust for this. The period of record used should, if possible, match that on which the normal precipitation is based.

The pattern of monthly average runoff, expressed in percentage of annual total, can be shown by the use of a bar graph,

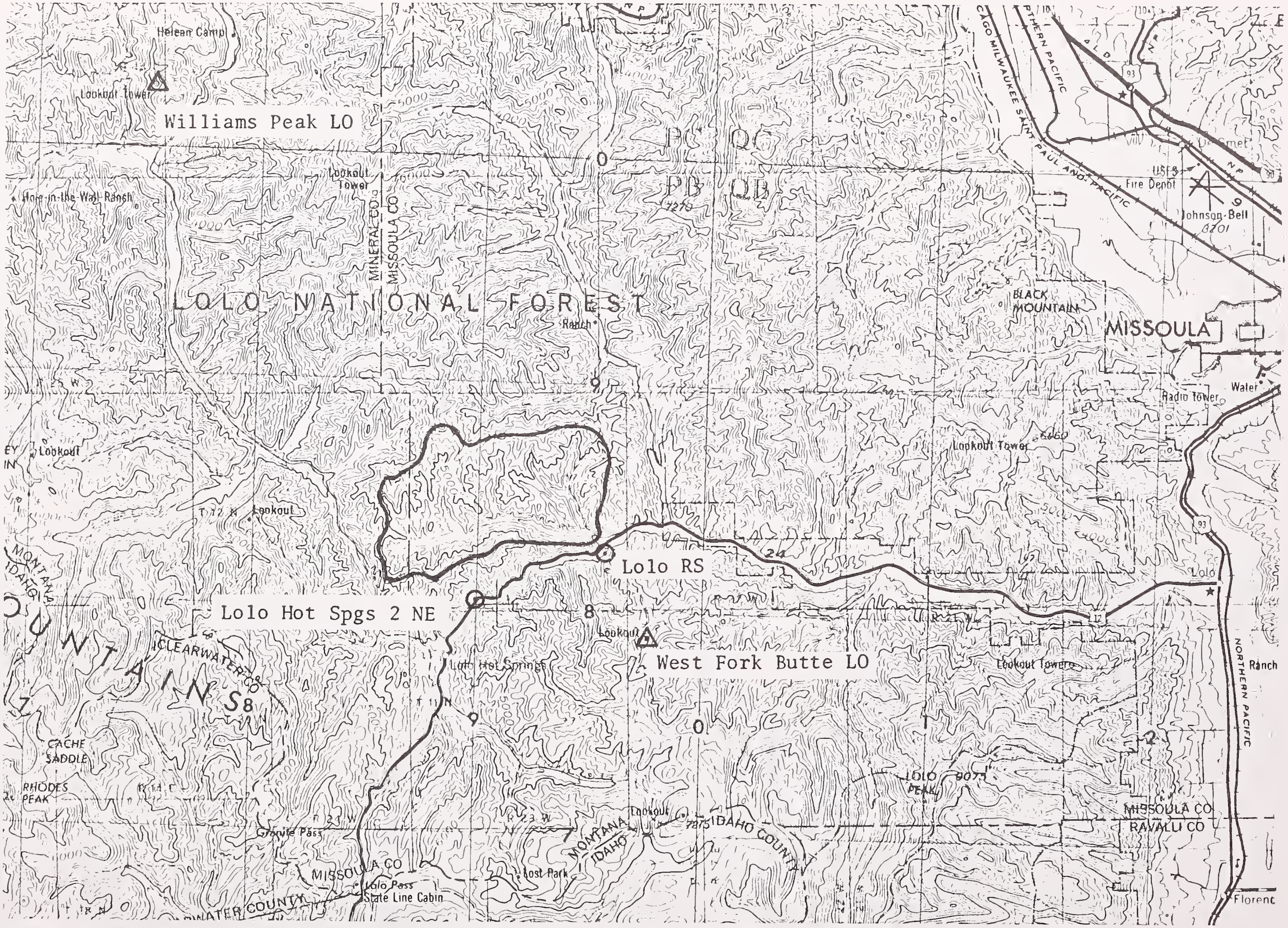


Figure 3.—Portion of map in U.S. Army Topographic Command Series, for sale by U.S. Geological Survey, showing topography of Howard Creek drainage (outlined), Montana, and locations of adjacent fire-weather or climatological stations. Elevation contours are at 200-ft intervals; sides of grid squares are 6 miles long.

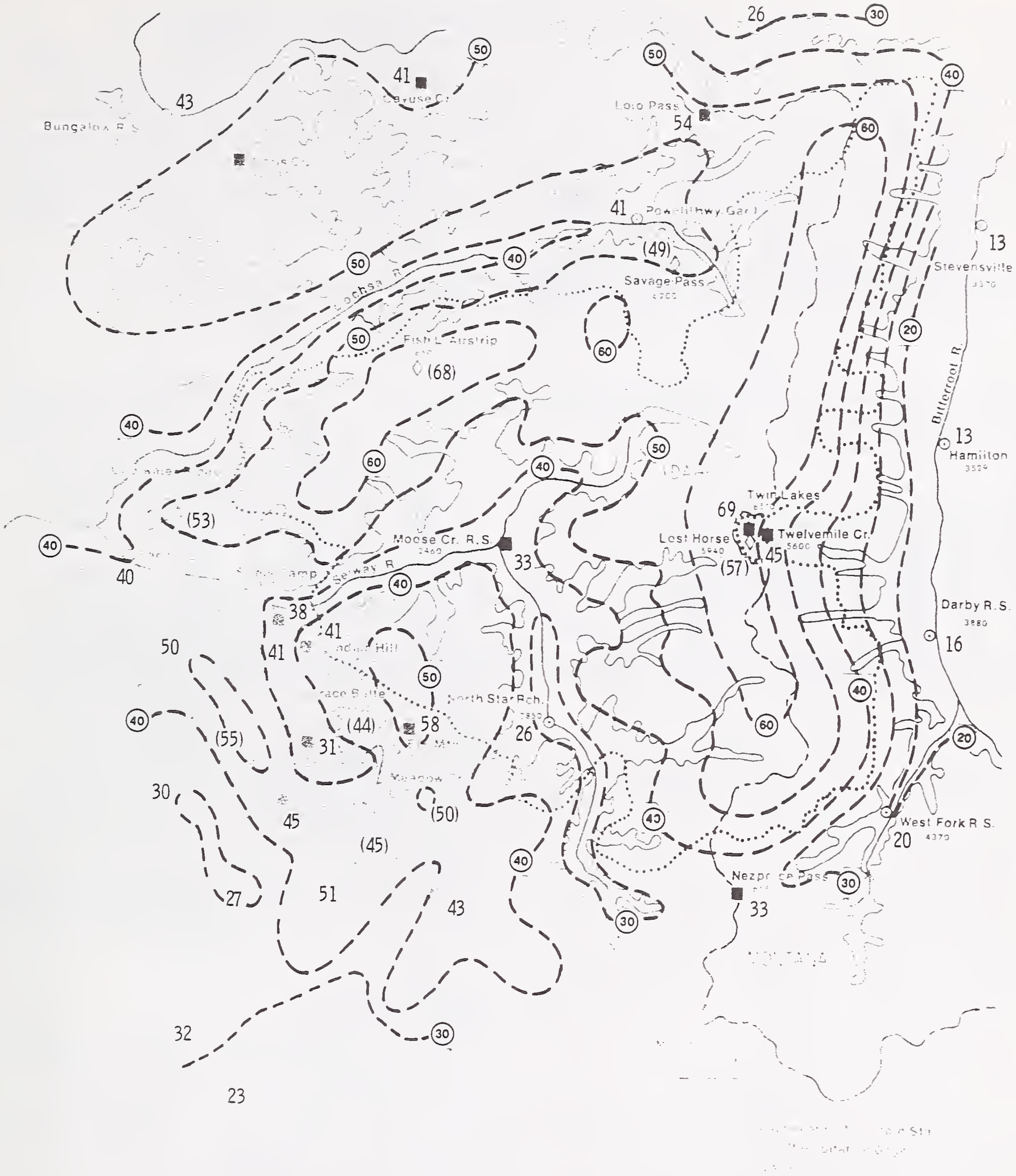


Figure 4.—Normal annual precipitation, inches, in or near Selway-Bitterroot Wilderness (outlined by dots), Idaho and Montana; based on or adjusted to 30-year period 1941–70. Amounts in parentheses are extrapolated from April 1 snowpack water content. Dashed lines (isohyets) are drawn and labeled at 10-inch intervals. Thin, irregular line is 5,000-ft elevation contour.

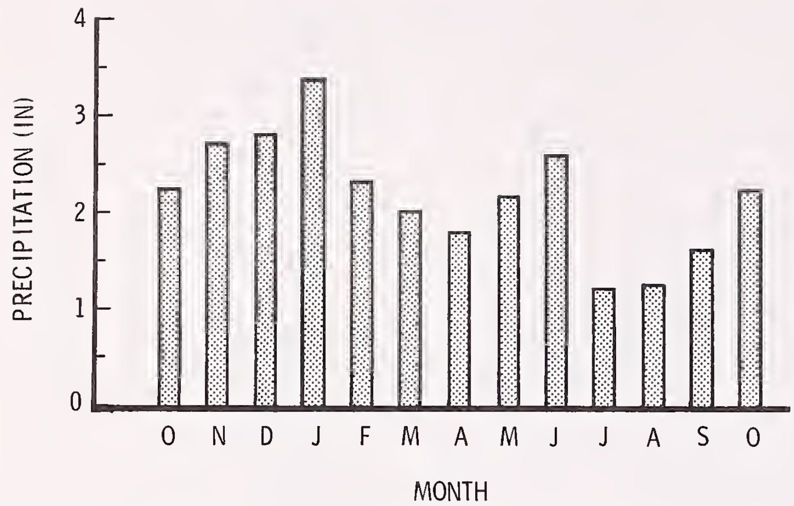


Figure 5.—Estimated normal (1941-70) monthly precipitation at climatological station near Howard Creek drainage, Montana, given in water-year sequence.

starting with October (first month of the water year); the cumulative water-year runoff, adding the monthly percentages, by a superimposed curve. The corresponding monthly and cumulative precipitation, as averaged from several stations in or near the drainage area, may be portrayed in the same diagram (fig. 6).

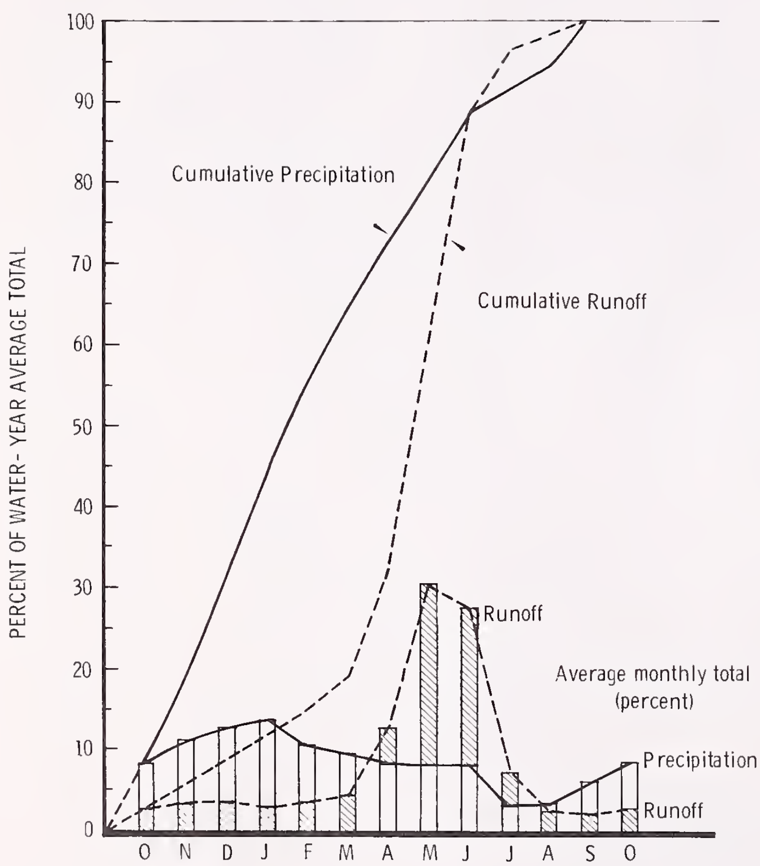


Figure 6.—Comparison of seasonal regimes of precipitation in Selway-Bitterroot Wilderness vicinity (average based on 5 stations) and Selway River runoff near Lowell, Idaho; based on or adjusted to 30 years 1941-70. Values are adjusted to 30-day months.

PRECIPITATION DURING FIRE SEASON

Average Rainfall:[5] 10-day and Monthly

A data summary obtainable by computer program is illustrated in table 6 (appendix). Use of a bar graph to depict 10-day average values is shown in figure 7 (lower panel). Though such details should ideally be based on or adjusted to the standard 30-year normal period, 20 years of data may suffice with smoothing (the need is evident from fig. 1). Methods of adjustment and smoothing are described in the final section of this report.

Monthly or Seasonal Extremes

These amounts, greatest and least observed, can be obtained in part from the above tabular output.

Frequency Distribution: Daily, 10-day, and Monthly Amounts

The frequencies are expressed as percentages of all observations in the corresponding time frame. Examples are found in tables 7 and 8 (appendix). These show a positive skewness typical of rainfall, particularly for the shorter time periods. That is, there is a wider range of amounts above the average than below. Correspondingly, the frequency of amounts below the average is greater.

The frequencies can be plotted in 10-day sequence, as in figure 7 (upper panel). In this example, the frequencies—given for the full season—were in part estimated through relationships with the corresponding 10-day average rainfall. An example of such relationship is seen in figure 8. For future reference we will term this type of graph, which can be used for other climatic elements, an "F-A" (frequency-versus-average) graph. Plotting of this graph is described in the final section.

In using this type of graph for frequency estimates, the horizontal scale is entered at the 10-day average amount for any portion of the fire-weather season. As an example, we may seek the frequency (or probability) of 24-hour rainfall $\geq$0.10 inch during September 11-20. Given the previously obtained normal average of 0.66 inch (fig. 7), projection of lines to and from the appropriate curve in figure 8 gives a frequency of 18 percent.

THUNDERSTORMS

Average Number of Days

The counted days or 24-hour periods include one or more separate storm occurrences. Tabulations may be for individual locations (from which the storms are observed) or for a broader area (storms observed from any one of several stations). For monthly resolution, averages should be based on at least 10 years of complete data; for 10-day periods, at least 15 or 20 years with some smoothing applied. Averages can be given in numbers of days (nearest whole number) or as percentages of all days.

It may be difficult, however, to obtain adequate thunderstorm data. On the Fort Collins fire-weather data library tapes,

[5]Here we will use the term rainfall, the form in which most of the precipitation occurs during the fire-weather season.

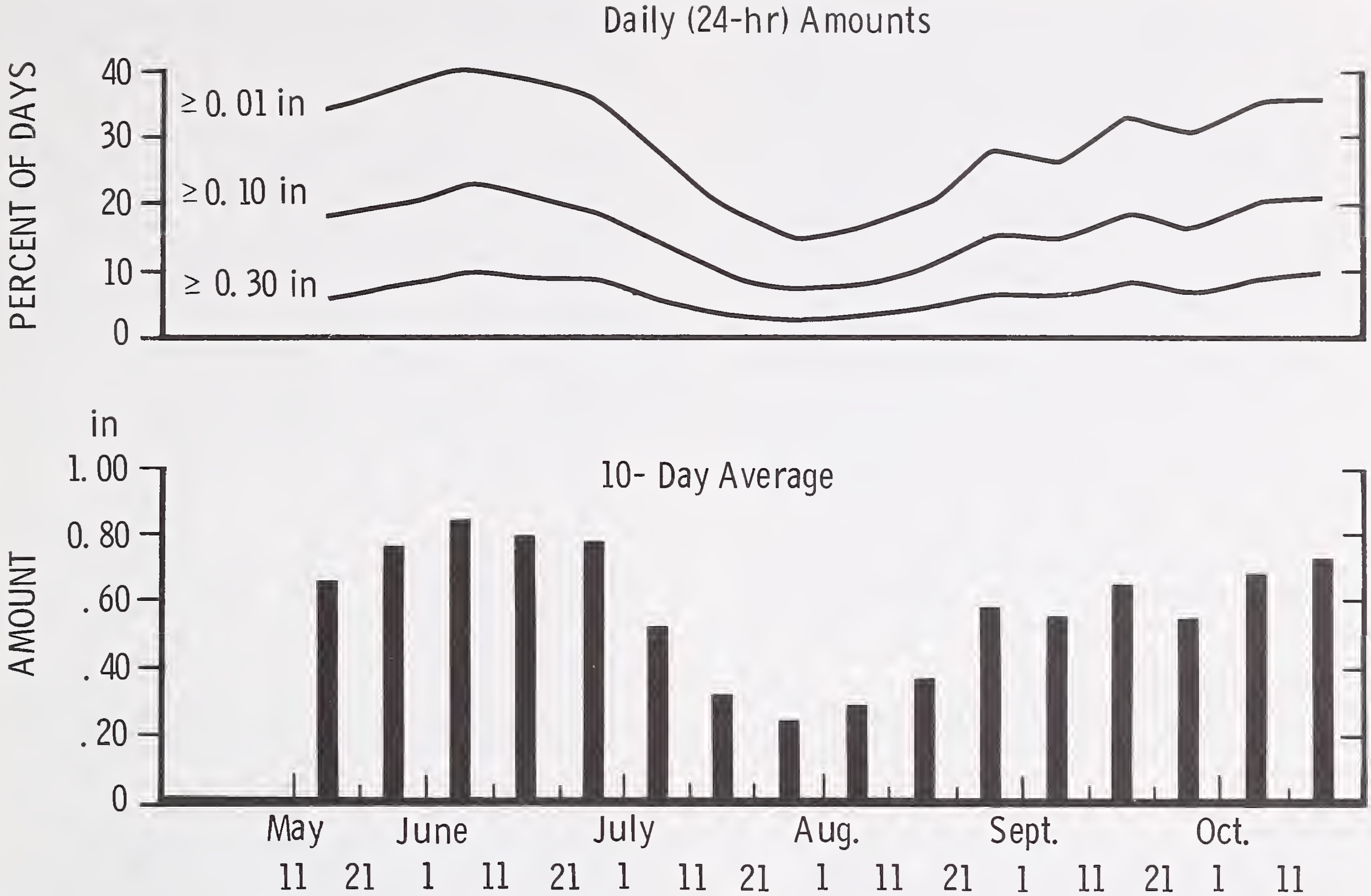


Figure 7.—Fire-season regime of precipitation estimated for lower canyon area, Howard Creek drainage. Montana. Lower panel: average 10- (or 11-) day accumulation, plotted at middle of periods. Upper panel: corresponding percentage frequency of specified daily amounts.

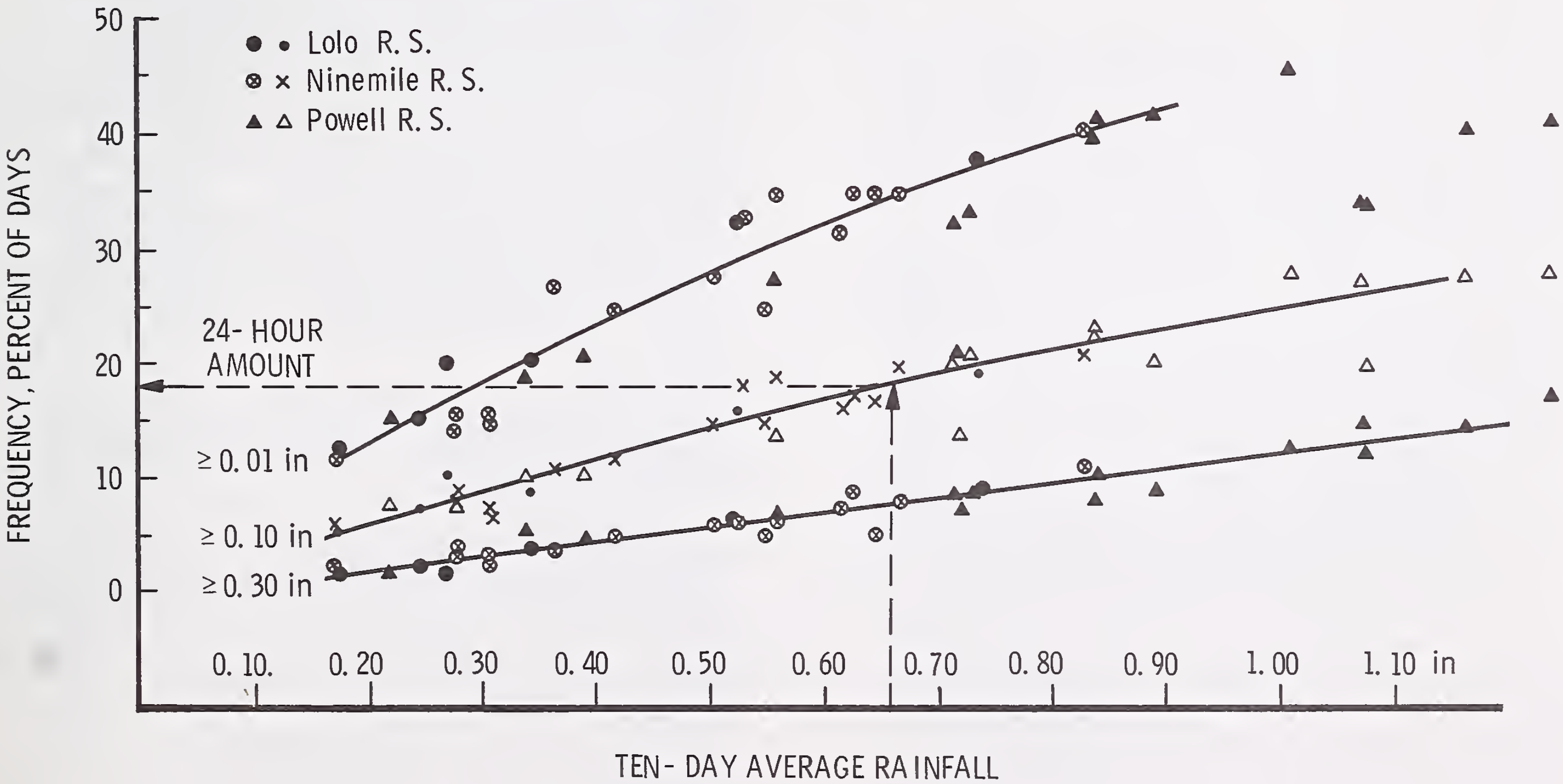


Figure 8.—"Frequency-versus-average" diagram, showing relationship between 10- or 11-day average total rainfall and percentage of days (24-hour periods) with the specified amounts; area surrounding Howard Creek drainage. Based on the indicated stations, May 11-October 20, 1954–70, except July 1-August 31, 1954–67, at Lolo Ranger Station. Projected lines and arrows show how to estimate frequency of ≥0.10 inch, given average rainfall of 0.66 inch.

the present AFFIRMS format provides for storm occurrence only by use of a Lightning Activity Level, part of the new National Fire Danger Rating System (Deeming and others 1972; Deeming and others 1977). This level is available for relatively few years to date. If the needed data can be gathered from original fire-weather forms or earlier tape printouts, the lookout observations should take precedence over those from ranger stations because of generally greater visibility and 24-hour duty.

The frequency of thunderstorm days may, alternatively, be estimated from tabulations (in "Local Climatological Data" summaries) for the Weather Service airport stations. Broad-scale monthly and annual patterns are shown on maps by the U.S. Weather Bureau (1952); an updated annual map is presented by Baldwin (1973). The criteria for thunderstorm occurrence differ somewhat. Present instructions for fire-weather stations include either visible lightning, as far as 30 miles away, or audible thunder. Thunderstorm days counted at the airport stations consider only audible thunder. Due to the traveling nature of storms, however, the two sets of data tend to become compatible. The tendency for more thunderstorm activity over mountain areas may present a greater source of difference.

TEMPERATURE, ANNUAL REGIME

Units, degrees Fahrenheit (F) or Celsius (C). Temperature, in our context, refers to measurements about 5 feet (1.5 m) above the ground surface.

Annual Mean

This is based on the 12 individual monthly averages or "means," which are taken as midpoint values between the average daily maximum and minimum temperatures. These values, which are close to actual 24-hour averages, smooth out some of the local daytime and nighttime effects.

Monthly Averages

The course of monthly average temperatures (both maximum and minimum) can be shown by curves (fig. 9). If 30-year normals are not available, averages based on 15 to 20 recent years will give a good approximation. The range between the warmest and coldest months may be noted; also the average daily ranges between maximum and minimum temperatures.

Interpretation factors.—Topographic setting, as well as elevation, can strongly affect the average temperature values. Year-round data are sparse for mountaintop and slope locations in the United States; some of the existing data have been specially obtained in government or university research studies. In making extrapolations for such locations, general relationships (described, for example, by Schroeder and Buck 1970) can help.

In general, afternoon (or daily maximum) temperatures decrease with elevation gain, though the average "lapse rate" varies with the region and time of year. Over the western United States, the lapse rates (between adjacent stations) average mostly between 3.5° and 5.0° F per 1,000 ft (6.4° and 9.0° C per 1 000 m) during spring and summer, but generally less in late autumn and early winter—when they are no more than 2.5° F per 1,000 ft (4.5° C per 1 000 m) in many areas. (These rates are based on data tabulations by the author.) An exception occurs near the Pacific coast, particularly in the California coastal ranges, where "marine-air" inversions are common during the summer. Nighttime (or daily minimum) temperatures may increase with elevation, due to inversions

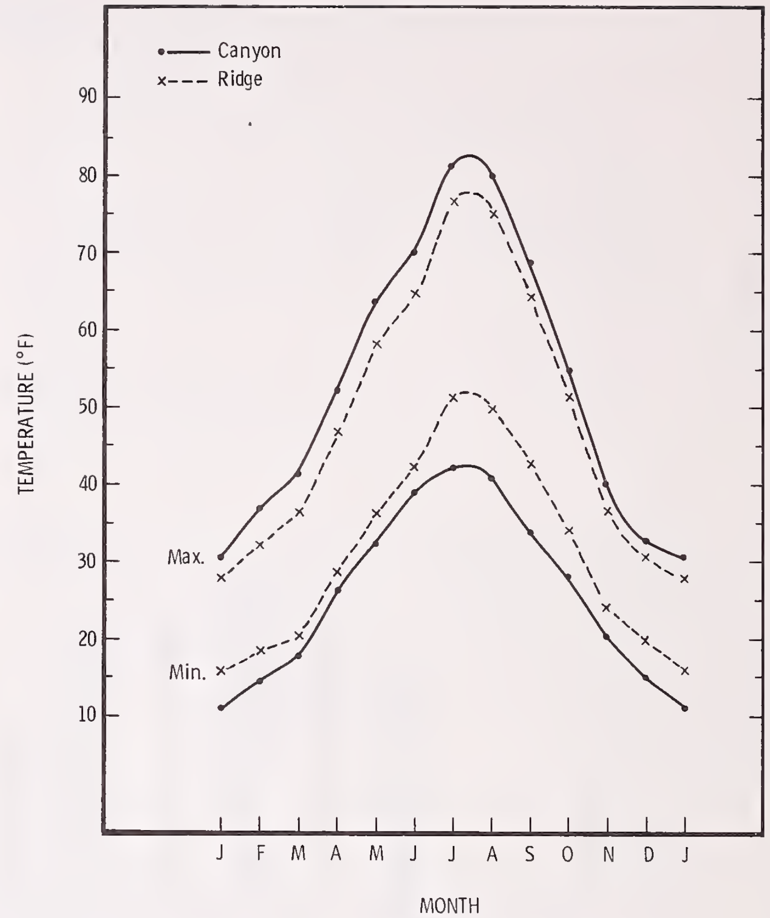


Figure 9.—Estimated normal (1941–70) monthly average daily maximum and minimum temperatures, for 24-hour period ending at midnight; Howard Creek drainage, Montana. At lower canyon location (4,000-ft elevation) and ridge location (5,400 ft).

from radiational cooling and downslope air drainage (Schroeder and Buck 1970). Further details are given in the section covering the fire season. Baker (1944) presents graphs of average temperature versus elevation in various mountain areas of the West. He does advise caution, however, because of the limited availability and representativeness of stations, particularly at higher elevations.

One should be aware of the effect of differing daily observation times on average maximum and minimum temperatures. As is discussed in the final section, there can be a resulting difference of 2° F (1° C) in the average daily maximum.

Extreme Values

These are the highest and lowest temperatures observed during a stated period of years. The extremes may be given for particular months or seasons.

Freezing Temperature Threshold Dates

These are the average last dates in spring and first dates in autumn with minimum temperatures ≤32° F (0° C) and ≤28° F (-2° C). The number of days between dates is commonly designated as the length of the frost-free season or growing season, but these are oversimplified terms.

For such tabulations, as in NOAA (1971) and annual "Climatological Data," State summaries, the National Climatic Center uses June 30-July 1 as the season division. For western mountain areas, such as the Northern Rockies, July 31-August 1 appears more suitable. This is normally the warmest time of

year; frosts or freezing temperatures may occur in June and early July but perhaps not again until late August or in September. If required, threshold dates for lower minimum temperatures, down to 16° F (-9° C), are also published.

RELATIVE HUMIDITY, ANNUAL REGIME

Units, percent. By definition (Schroeder and Buck 1970), relative humidity is the percentage ratio of the air's actual water vapor pressure to the saturation (or maximum possible) vapor pressure at the existing temperature. This maximum pressure increases with increasing temperature. Thus, if there is little change in actual vapor pressure, the relative humidity varies inversely with the temperature. This relationship largely accounts for the occurrence of minimum relative humidity values in the afternoon and maximum values near dawn. The vapor pressure is directly related to the dewpoint—the temperature to which air must be cooled to reach saturation and condensation.

Monthly Averages

Outside the season of fire-weather observations, available relative humidity data are limited to the network of airport (or airways) weather stations. (This excludes older data from former stations mostly in downtown city locations.) Before 1982, averages were given in monthly "Climatological Data," State summaries, for the times corresponding to 0000, 0600, 1200, and 1800Z (Greenwich meridian time). These hours range from 1 and 7 a.m. and p.m. eastern standard time to 4 and 10 a.m. and p.m. Pacific standard time. Averages are also given for the intermediate 3-hourly times in "Local Climatological Data."

As with temperature, monthly averages based on 15 to 20 years will give a good approximation of the normal. Twenty-four hour averages can be approximated from those of the above times. The averages at the airport stations may serve only as an indicator of the monthly trends in the forest and mountain areas; they should be more representative of grassland areas. Averages (24-hour) can also be interpolated, within perhaps 5 or 10 percent accuracy, from lines drawn on maps in ESSA (1968); the lines have been adjusted somewhat over the mountain areas.

TEMPERATURE AND RELATIVE HUMIDITY DURING FIRE SEASON

These two elements are discussed together—because of their relationship (described above) and because the data are summarized in the same types of tables and graphs. The temperature in this context is often termed the "dry bulb."

Afternoon Averages, 10-day and Monthly

Examples of computer program output are shown in table 9 (appendix); graph presentation of averages in figure 10. A map may be included for a peak season month (fig. 11). As indicated by figure 2, 10-day details should, if possible, be based on at least 20 years of data at an unchanged observation time; however, 15 years, together with smoothing (final section), may suffice.

For estimating averages at another location, where elevation difference is more than a few hundred feet (100 m), appropriate lapse rates may be applied. Using data from adjacent lookouts, the afternoon temperature lapse rate between ridgetop or mountaintop locations should be close to 3.5° or 4.0° F per 1,000 ft (6.4° to 7.3° C per 1 000 m) over much of the mountain West. The corresponding average relative humidity usually increases with elevation, with a change of about 3 percent per 1,000 ft (305 m) in the Northern Rocky Mountains. An adjustment of 4 percent per 1,000 ft is indicated in the Pacific Northwest region by Graham and Lynott (1971). Afternoon temperature lapse rates from canyon or valley locations to adjacent ridgetops should, outside the Pacific coastal influence, generally average somewhere between 3.5° and 5.0° F per 1,000 ft (6.4° and 9.0° C per 1 000 m). However, temperatures at slope locations can easily differ by 3° F (2° C) or more from laspe rate estimates, depending on aspect as well as vegetative cover.

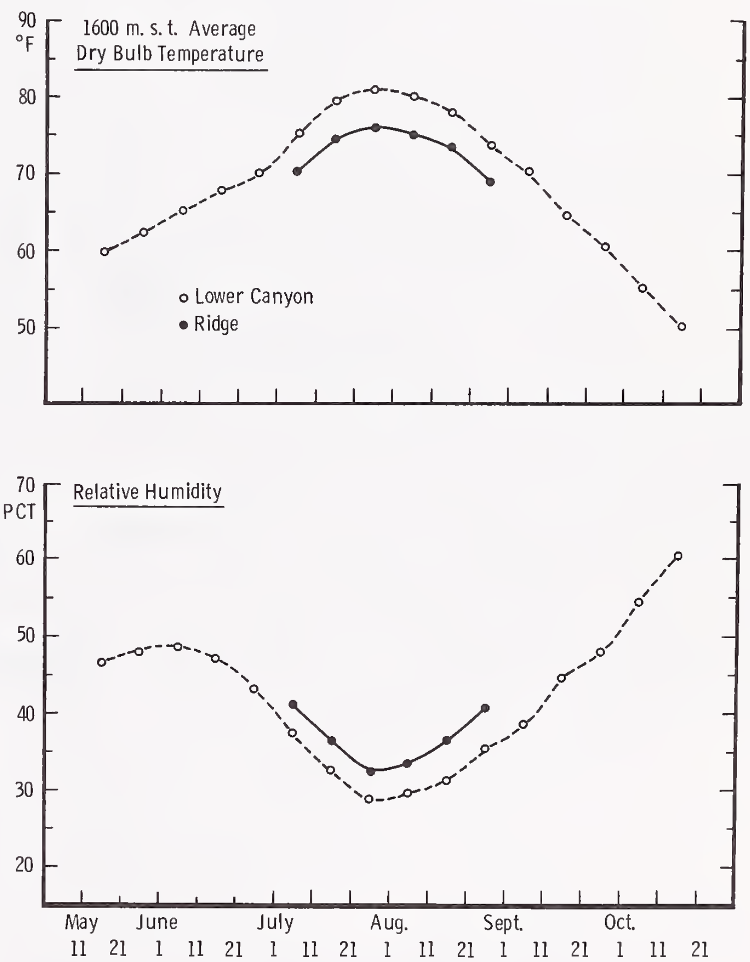


Figure 10.—Fire-season regimes of 10- or 11-day average dry bulb and relative humidity at 1600 m.s.t., Howard Creek drainage. Curves are fitted to smoothed 1954–70 averages (plotted at middle of periods) estimated for lower canyon (4,000 ft) and ridge (5,400 ft) locations.

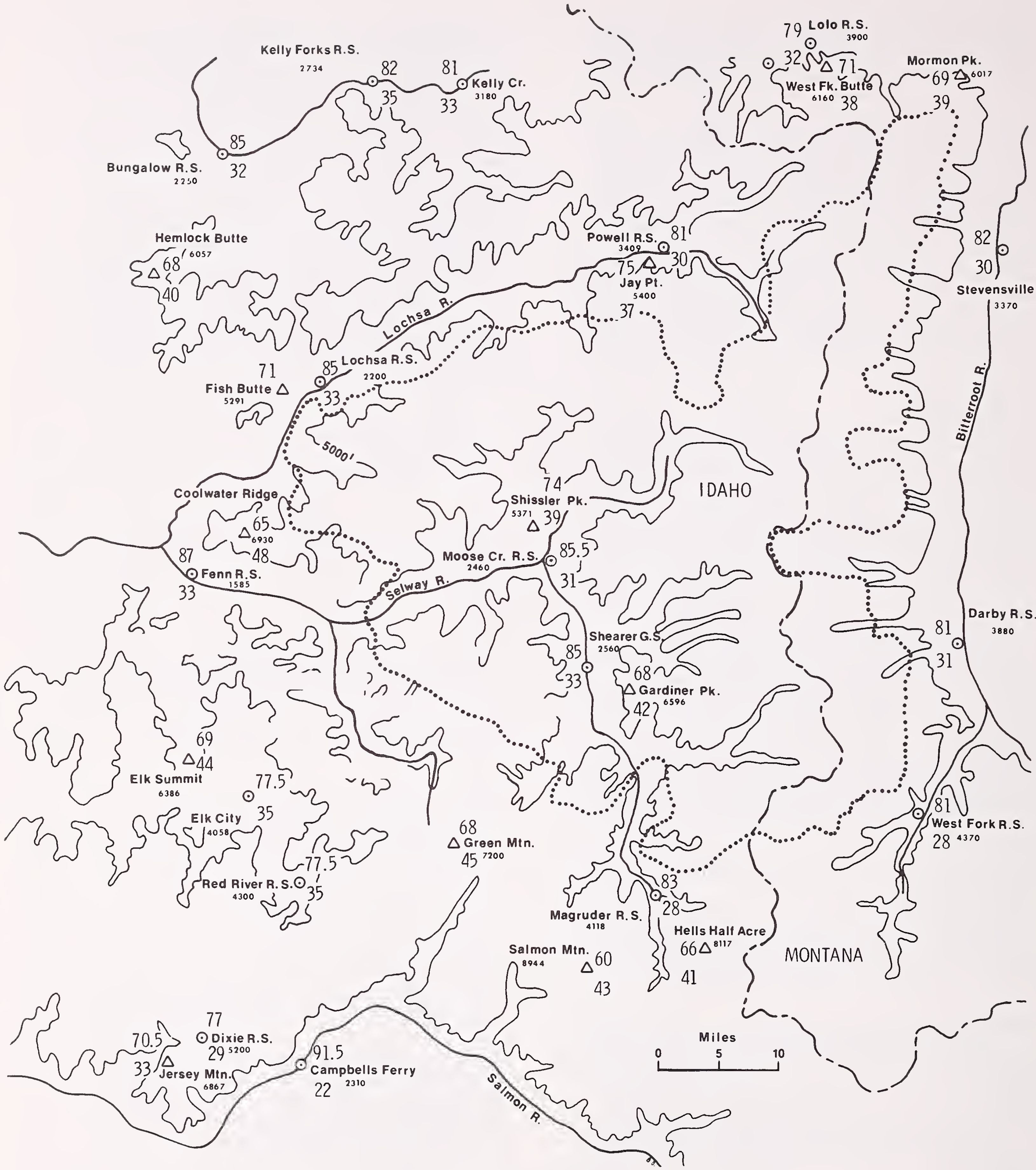


Figure 11.—Average dry bulb temperature, °F (top number), and relative humidity, percent (bottom), at 1500 P.s.t., July, in or near Selway-Bitterroot Wilderness.

Afternoon Frequency Distributions

Examples are shown in table 10 (appendix) and in figure 12. The frequencies for such a figure are obtained by summing the percentages given in each of the table classes lying above the specified dry bulb thresholds and below the specified relative humidity thresholds. These threshold values are generally at intervals of 10° F (5° C) and 10 percent, respectively. The plotted frequencies may be smoothed (as described in the final section) or, as in figure 12, the fitted curves smoothed. Using these curves, various percentile values can be interpolated for any portion of the season. Thus, in figure 12, the 10th percentile value of relative humidity during July 1–10 is about 16 percent.

For locations with no data or with only a short record, the frequencies can be estimated from adjacent stations by use of "F-A" relationships previously described for precipitation. Examples for dry bulb are given in figure 13; for relative humidity in figure 14. Thus, using figure 13 (left panel), if the 10-day average dry bulb is 80° F (27° C) at a canyon location, the estimated frequency of days with ≥90° F (32° C) is 12 percent. Separate graphs are required, at least for dry bulb, for the groupings of ranger stations and lookouts. The sets of curves would differ further for higher-elevation lookouts.

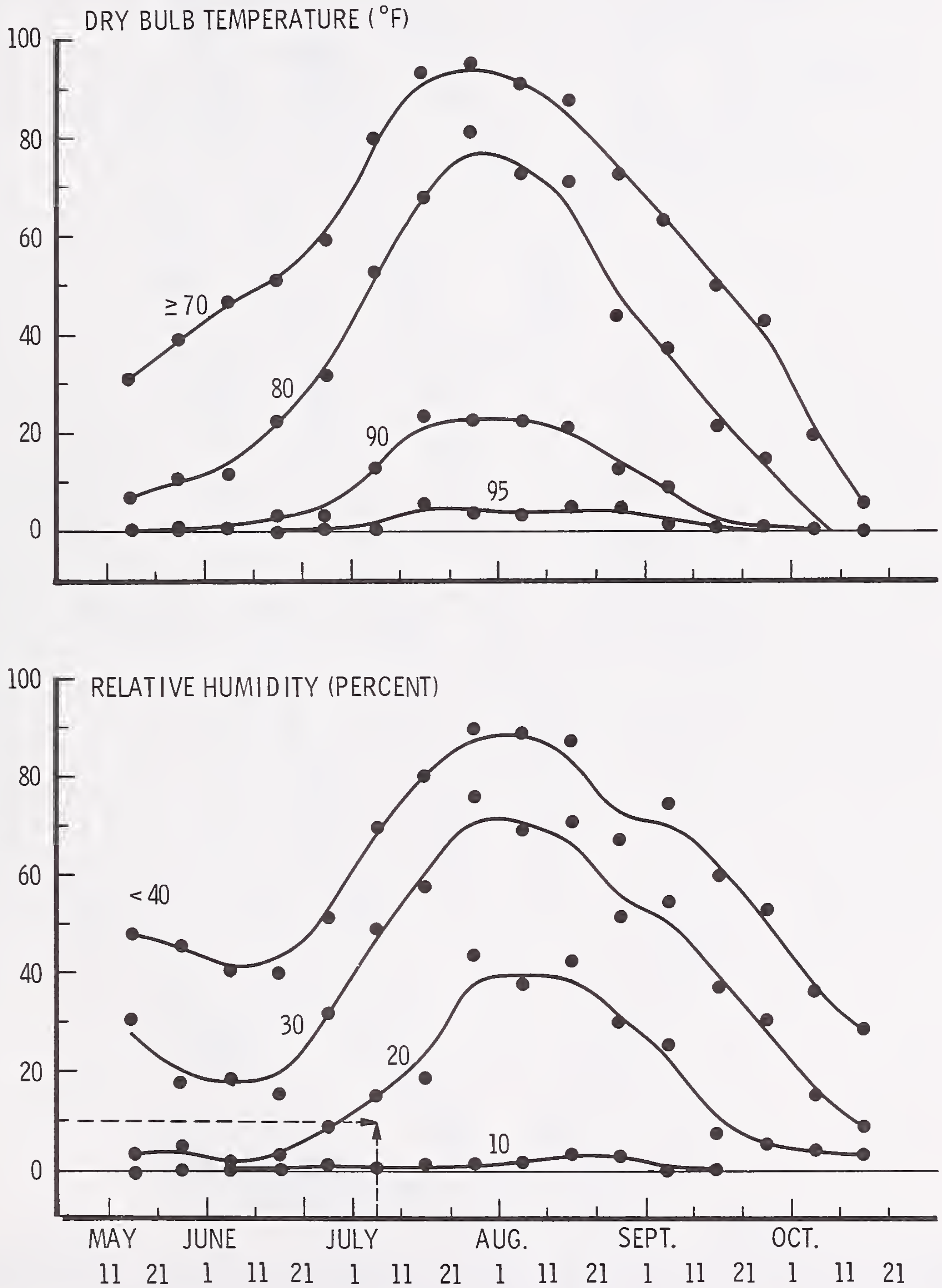


Figure 12.—Fire-season frequencies of specified dry bulb (upper panel) and relative humidity (lower panel) at 1600 m.s.t., Ninemile Ranger Station, Mont.; based on data during 1954-70. Curves, smoothed by 1-4-1 weighting, are fitted to frequencies (plotted at middle of 10- or 11-day periods). Projected lines and arrows show how to estimate 10th percentile value of relative humidity for July 1-10.

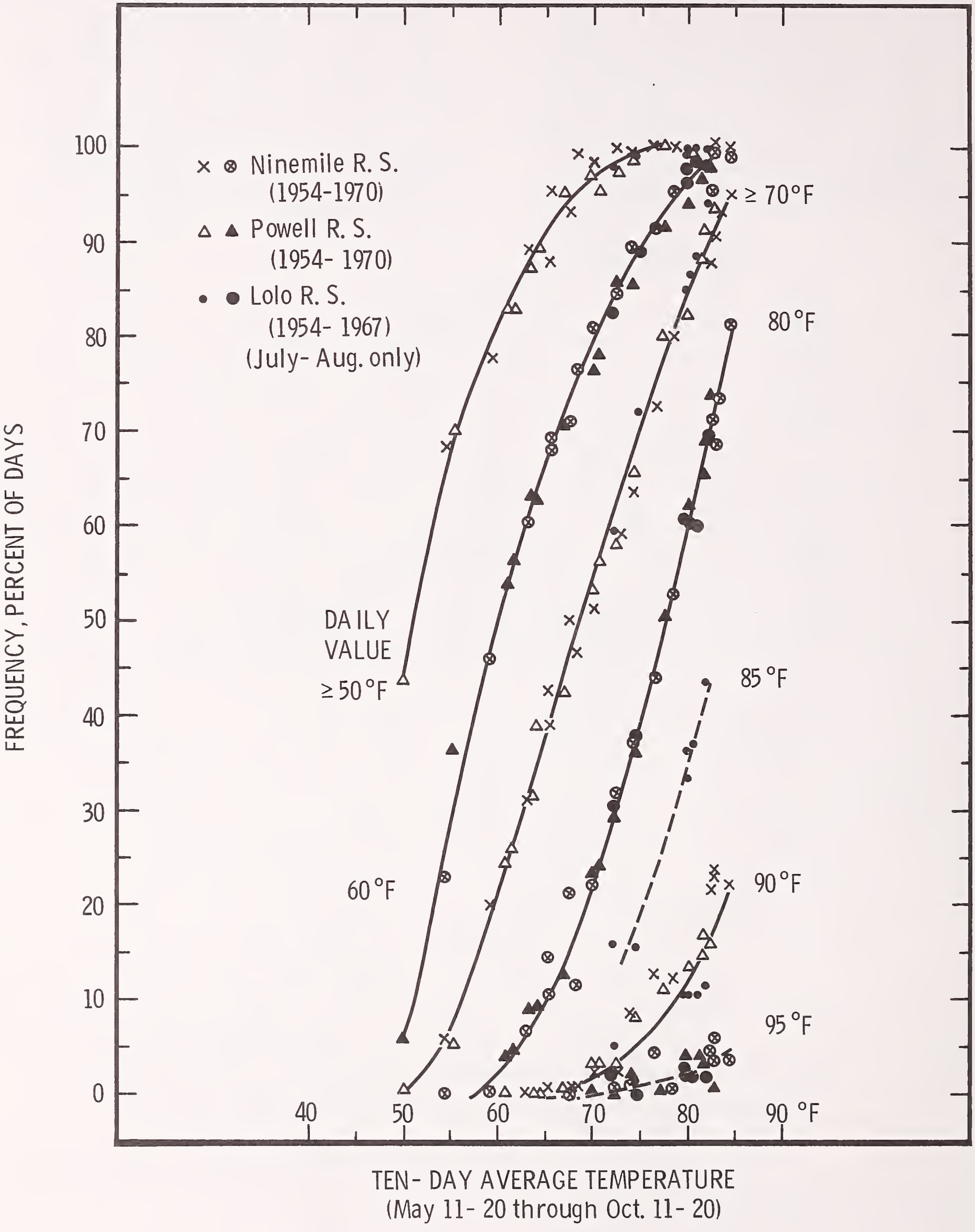
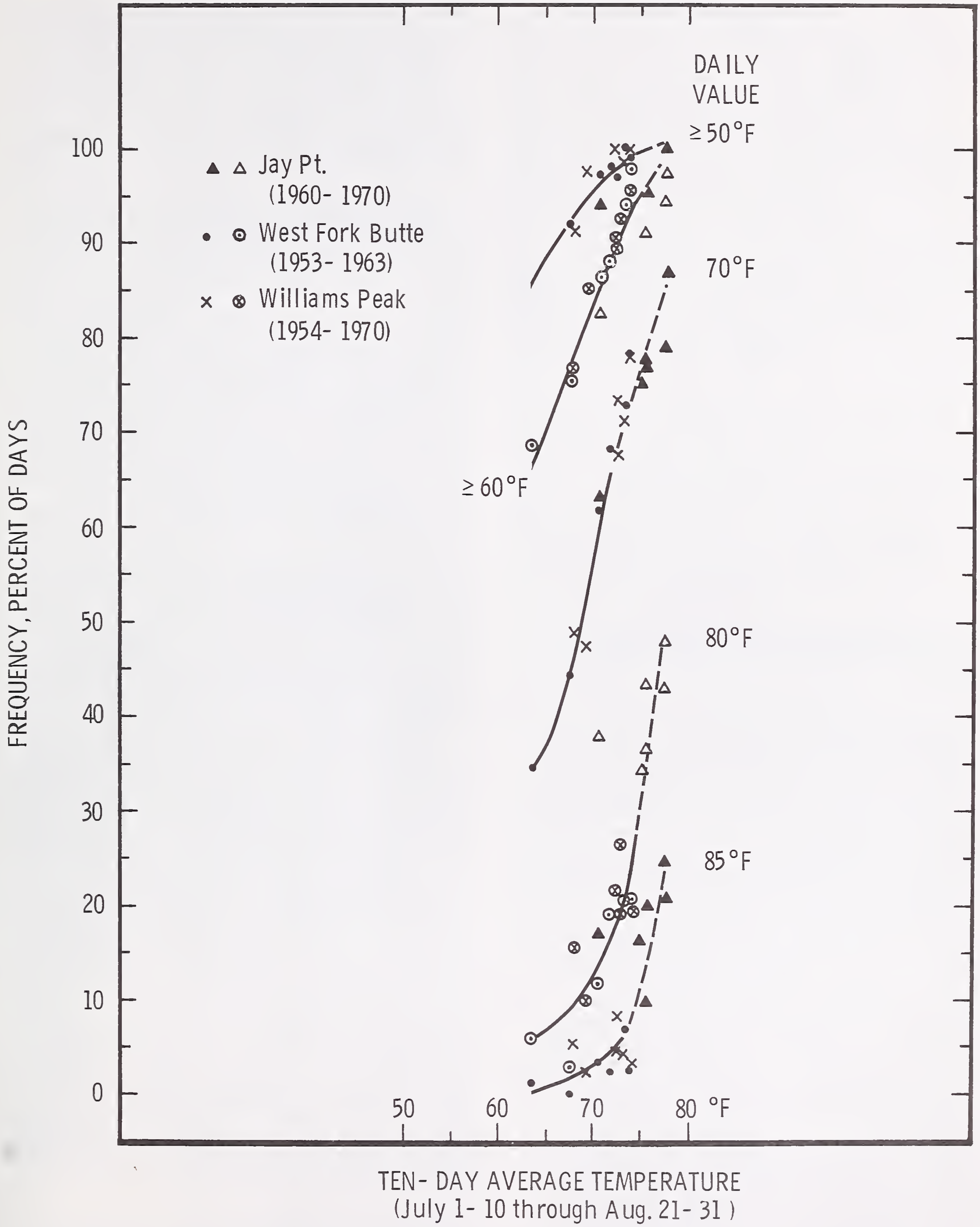


Figure 13.—"Frequency-versus-average" relationships (see fig. 8) for dry bulb at 1600 m.s.t.; area surrounding Howard Creek drainage. Based on indicated ranger stations (left panel) and lookouts (right panel).



DAILY VALUE
≥50°F
70°F
80°F
85°F
≥60°F
Jay Pt. (1960- 1970)
West Fork Butte (1953- 1963)
Williams Peak (1954- 1970)
FREQUENCY, PERCENT OF DAYS
0
10
20
30
40
50
60
70
80
90
100
50
60
70
80 °F
TEN- DAY AVERAGE TEMPERATURE
(July 1- 10 through Aug. 21- 31)

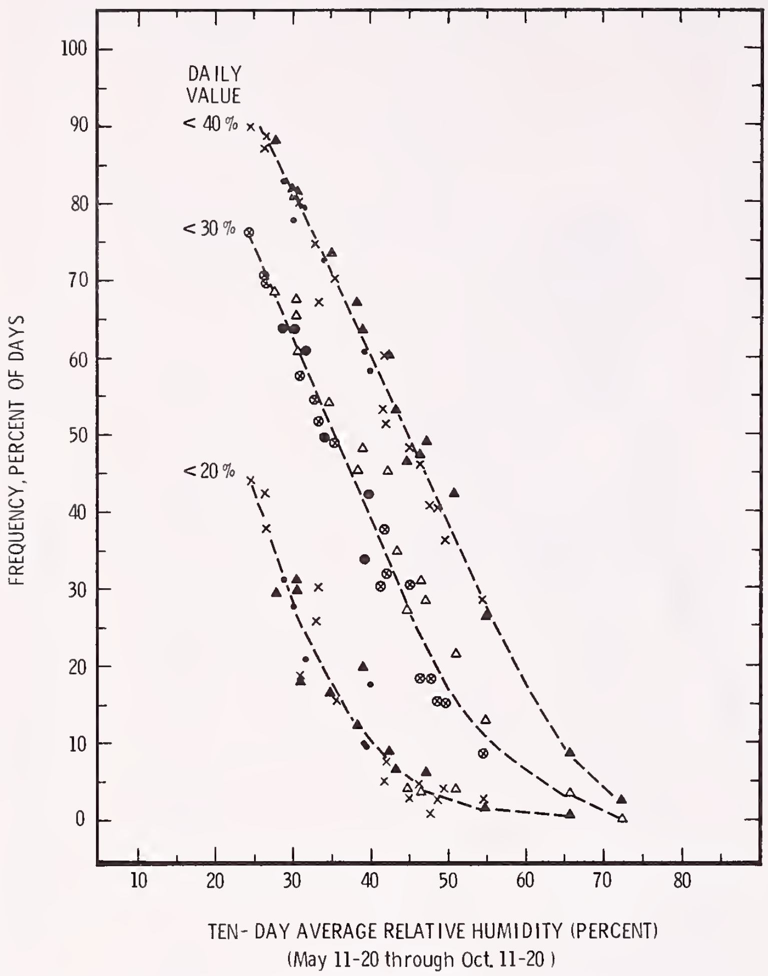


Figure 14.—"Frequency-versus-average" relationships for relative humidity at 1600 m.s.t., based on ranger stations as in figure 13.

Daily Maximum and Minimum Temperatures

Examples of summarized data are shown in tables 11 and 12 (appendix). The seasonal trend of average daily maximum temperature closely parallels that of the afternoon dry-bulb (as graphed in fig. 10). Likewise, average lapse rates of maximum temperature are similar to those already noted for the dry bulb. Included in this similarity is an overall lapse rate of about 4.0° F per 1,000 ft (7.3° C per 1 000 m) for spring and summer maximum temperatures in the mountain area of western North Carolina (from data listed by Cox 1923).

The lapse rate of 24-hour average temperature is brought closer to (or below) the sometimes quoted climatic lapse rate of 3.3° F per 1,000 ft (6.0° C per 1 000 m) (Baker 1944; Baldwin 1973) by the generally smaller lapse rates of nighttime (and daily minimum) temperatures. These smaller rates are related to the inversions that typically occur in fair weather. In the northern Rocky Mountain area, average minimum temperatures during July and August are higher at lookouts than in canyons or valleys 3,000 to 5,000 ft (900 to 1 500 m) lower in elevation. The average lapse rates, thus, do not necessarily represent a continuous gradient along a slope.

Where the slope has an open exposure, average nighttime temperatures may increase 10° F (6° C) or more within a rise of 1,000 ft (300 m) above a valley, peaking in the "thermal belt." (Examples are given by Cox 1923; Hayes 1941; Reimann 1959; MacHattie 1970.) This belt, where the highest 24-hour average temperature occurs, is centered at or near the typical inversion top, above which the nighttime temperature decreases. The decrease appears to average near 2.0° to 2.5° F per 1,000 ft (4° C per 1 000 m) in the Northern Rockies and western North Carolina. In narrow canyon areas, particularly where slopes are well forested, inversions in summer may average only 2° to 4° F in the lower 1,000 ft (1° to 2° C in 300 m); examples observed in the Selway-Bitterroot Wilderness area in Idaho are given by Finklin (1983).

Nighttime (Maximum) Relative Humidity

Because of the data uncertainties, only monthly averages are suggested. Observations of the daily maximum (and minimum) relative humidity, from hygrothermograph traces, are recorded at many fire-weather stations, but caution is advised (footnote 2). Alternatively, the average maximum relative humidity may be approximated from the generally inverse relationship with temperature. A simple procedure is to estimate the average maximum humidity as the value found in a psychrometric table (available in Fischer and Hardy 1976), given as inputs the average daily minimum temperature and the corresponding monthly average afternoon dewpoint. This may be done for valley and canyon locations but, as discussed below, some adjustment of dewpoint is recommended at least for higher terrain. The dewpoint may itself have to be obtained indirectly from the psychrometric table, as it is not available from the tapes at the National Fire-Weather Data Library.

To illustrate the simple procedure, we will use respective minimum temperature and afternoon dewpoint averages of 50° F and 44° F at a station elevation of 3,000 ft (915 m); the appropriate psychrometric table then shows a relative humidity of 81 percent. Accuracy of such an estimate much depends on how close the afternoon dewpoint is to that actually occurring around dawn. In the above example, a 2° F (1° C) difference in dewpoint would yield a 6 or 7 percent difference in the relative humidity estimate.

At valley locations with strong nighttime cooling, particularly in forest areas, the minimum temperature may average slightly lower than the afternoon dewpoint. An example is seen in comparing table 11 with table 9 (appendix). Such a condition indicates that dew or frost formation has removed moisture from the air. The relative humidity (at instrument shelter level) may then average about 95 percent around dawn.

For ridgetop or mountaintop locations, estimates of summer nighttime relative humidity should generally use a dewpoint lower than the observed afternoon value; lookout data suggest a difference of at least 3° F (2° C) in the western States. This difference follows from the typical diurnal variation during fair weather, related to upslope breezes during the day and downslope breezes at night (Schroeder and Buck 1970). The daytime air movement from lower elevations brings relatively high afternoon dewpoints on the mountains. At night, the dewpoints tend to decrease to those of the surrounding atmosphere. This change contributes to typically smaller relative humidity recovery than in the valleys and canyons, but the smaller nighttime temperature drop on the mountains is a greater factor. By dawn, the humidity may average 30 percent or more lower than in canyon and valley bottoms.

WIND, ANNUAL REGIME

Units of speed, miles per hour (mi/h) or kilometers per hour (km/h). Directions are those from which the wind is blowing.

The standard surface measurements are at a height of 20 ft (6 m) above the ground in an open area.

As with relative humidity, year-round wind data are limited mostly to the network of airport (or airway) stations. Caution is advised in applying these data to forest and mountain areas. Windspeeds and directions can be greatly modified by surrounding timber and the local topography. Monthly average speeds given in ESSA (1968) and "Climatological Data," State summaries, are based on the entire day; averages at 3-hour intervals are given in "Local Climatological Data." The latter two publications also list the resultant speeds (obtained by vectorial averaging), which for our purposes should not be used. Prevailing (most frequent) directions, rather than resultant directions, are given only in ESSA (1968).

WIND DURING FIRE SEASON

Afternoon Direction and Speed

Monthly data resolution should be adequate. The standard windspeed at fire-weather stations is a 10-minute average taken at the afternoon observation time. While in many areas this time may closely represent the hour of highest average speed, winds can be stronger at other times on individual days. Within the 10-minute observation period, higher speeds can be expected over shorter durations. Crosby and Chandler (1966) found, at Salem, Mo., the probable maximum 1-minute average speed was generally 4 or 5 mi/h (up to 8 km/h) higher than the 10-minute average.

A basic summary of wind data is illustrated by table 13 (appendix). This gives combined frequencies of speeds and directions, together with average speeds. Directions are tabulated to eight points of the compass. Such a summary should be based on at least 10 years of data.

Prevailing wind directions in mountain valleys or canyons are generally up-valley (toward higher elevations) during the afternoon; opposing broader-scale, or "general," winds may dominate in less sheltered valleys. Exceptions have been noted to result from sea-breeze influences in parts of California (Schroeder and Buck 1970); also from spillover, through a low pass, of an up-canyon breeze from the other side of a mountain ridge. The afternoon winds are normally stronger at the lookout locations than at nearby ranger stations but overall elevational gradients cannot be given (fig. 15). The differences between canyon and mountaintop may vary more with local topographic effects or exposure than with elevation. Speeds at adjacent airports, usually in more open locations, tend to average higher than those observed at ranger stations.

Afternoon Frequency of Stronger Winds

The percentage frequencies of days with various threshold windspeeds can be obtained (by appropriate summation) from the computer output illustrated in table 14 (appendix); also from table 13 (appendix). As an example, using table 14, the frequency of July days with an observation of ≥ 15 mi/h (24 km/h) at West Fork Butte is found by adding the values in the "total" rows below the boxes for speeds of 15 to 19 mi/h and ≥ 20 mi/h. These totals (given in percent and tenths, decimal point omitted) are 4, 78, 51, 23, 8, 4, 8, 12, 8, 8, 4, and 4—adding up to 212, or 21 percent of all days.

An "F-A" graph may be plotted, relating average (monthly or seasonal) windspeed at a station and frequency of observed higher windspeeds (fig. 16). This requires data from several stations in an area, representing a sufficient range in average speed. Frequencies can then be estimated at other locations for which only the average speed is available.

Nighttime Wind

Except for early morning fire-weather observations prior to 1950 (and data from research studies), nighttime wind conditions in specific forest areas are left to inferences and generalities. In general, during the fire season, nighttime winds in mountain topography are downslope and down-valley (or down-canyon). They will usually be very light in bottom locations where temperature inversions are strong (as indicated by large daily temperature ranges). Higher speeds may be expected, however, where the down-canyon direction is alined with that of the "free-air" wind.

On the higher mountaintops, prevailing winds should generally continue from near the afternoon directions. Windspeeds on such terrain have been characterized as tending to increase at night (Baughman 1981). Available observations give mixed findings, with nighttime decreases on some mountains in the southwestern United States (Court 1978). Average nighttime increases did occur at two of three lookouts that had continuous recording charts in southern Idaho (Hanna 1933). The average diurnal curves, covering 4 or 5 summers, showed distinct differences, reflecting the importance of local topographic factors. Mountaintop winds may decrease by morning. At lookout stations in the Northern Rockies, speeds at the former 8 a.m. observation time averaged anywhere from 1 to 6 mi/h (up to 10 km/h) lower than in midafternoon. Hourly data from RAWS locations will provide more specific knowledge and will increase the base from which estimates may be made for other locations.

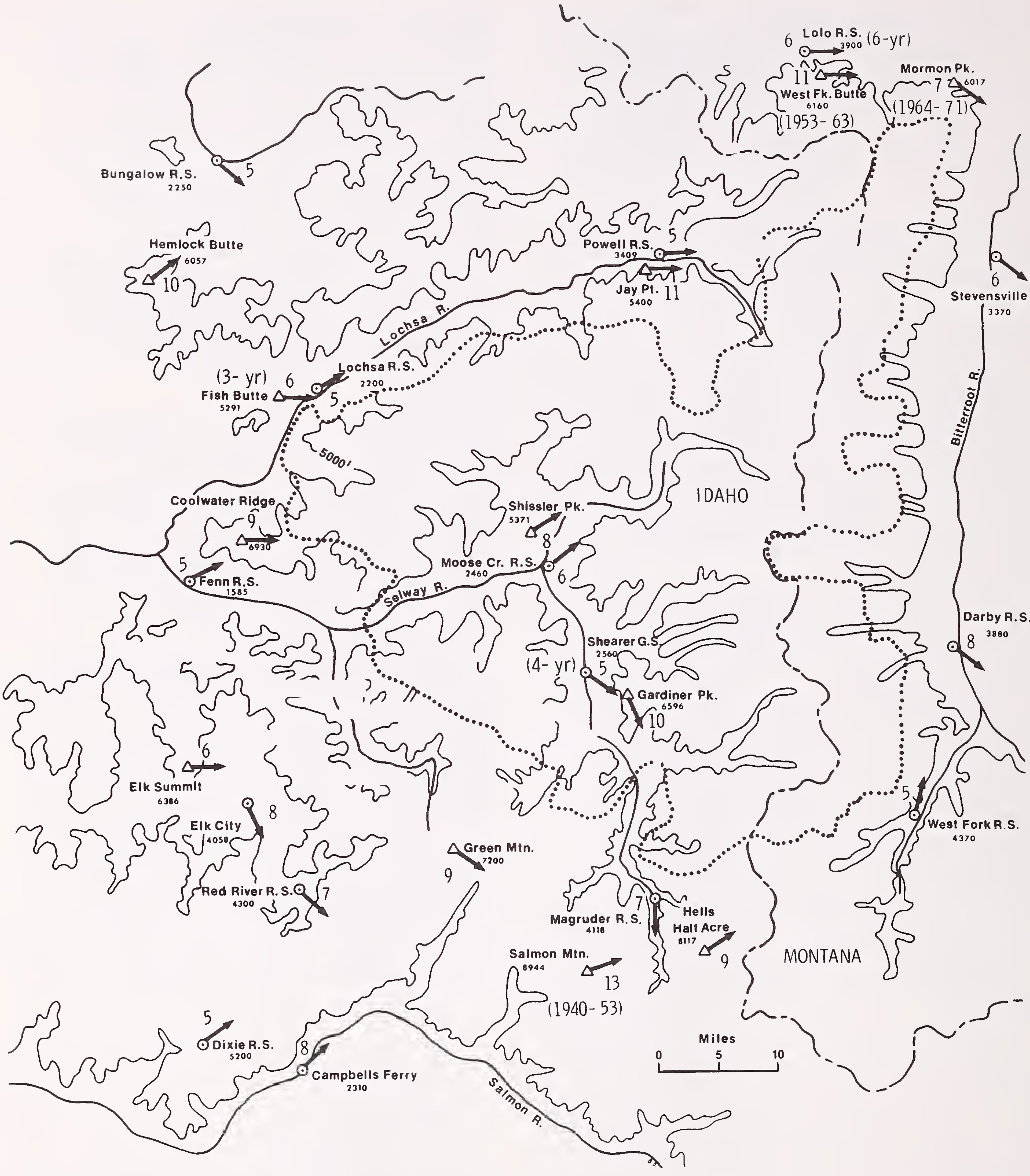


Figure 15.—Average windspeed, in miles per hour, and prevailing (most frequent) direction at 1500 P.s.t., July and August combined; in or near Selway-Bitterroot Wilderness. Based on 1961–70, except as noted. Arrows point downwind.

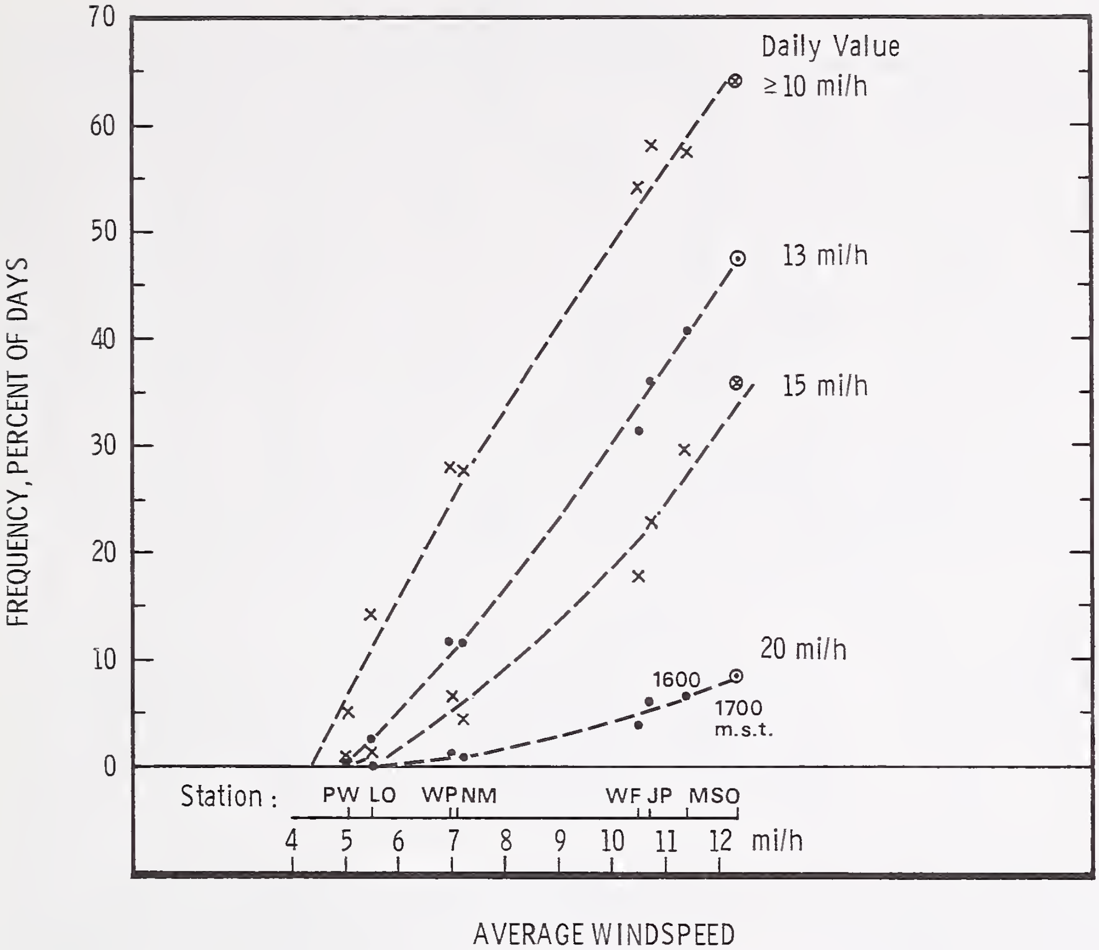


Figure 16.—"Frequency-versus-average" relationships (see fig. 8) for windspeed at 16 m.s.t., except as noted, July-August; Howard Creek drainage vicinity. Based mostly on 10 to 17 years during 1954–70.

COMBINED FIRE-WEATHER ELEMENTS, FREQUENCY DISTRIBUTIONS

Ten-day frequencies of various combinations of afternoon temperature (dry bulb), relative humidity, and windspeed can be obtained from summaries such as table 14 (appendix). The frequencies (or probabilities) can also be obtained from graphs, with their possibly easier and broader use, as follows.

Temperature and Relative Humidity

For joint probabilities involving these two elements, the procedure first obtains the frequency of the specified dry bulb alone (fig. 12, upper panel). This frequency is then multiplied by that of having the specified relative humidity when given the same dry bulb.

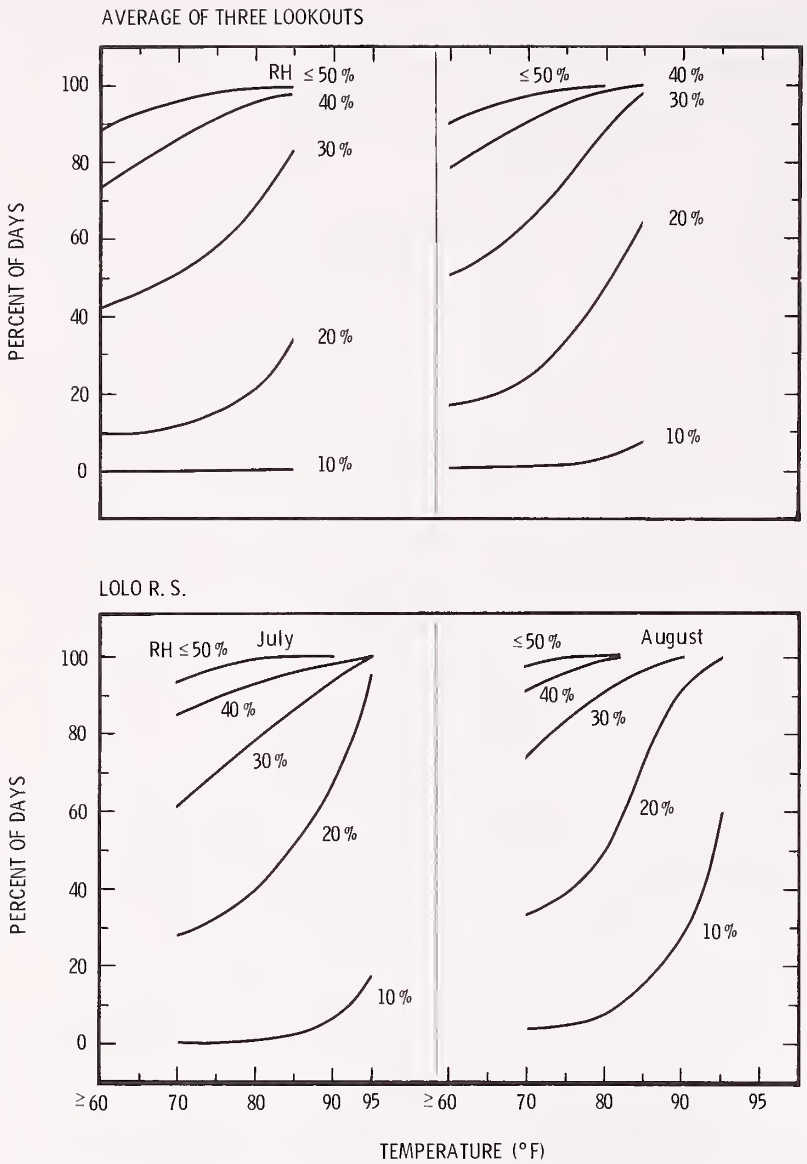


Figure 17.—Percentage frequency of July and August days with relative humidity reaching specified values at 1600 m.s.t., for a given dry bulb temperature threshold; Howard Creek drainage vicinity.

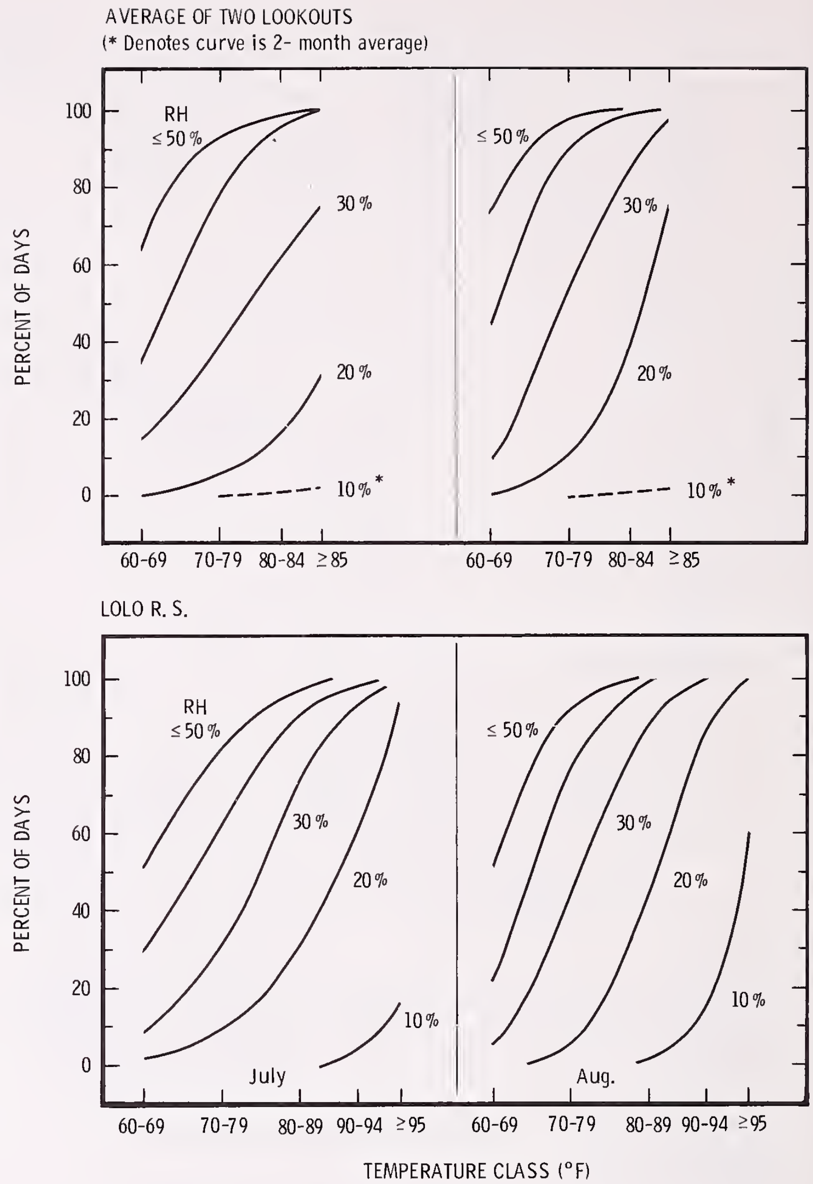


Figure 18.—Percentage frequency of July and August days with relative humidity reaching specified values at 1600 m.s.t., for a given dry bulb temperature range (class); Howard Creek drainage vicinity.

Graphs for the second step, if drawn manually, proceed from the monthly frequencies in table 14 (appendix); the frequencies are accumulated, without respect to windspeed, in descending order of dry bulb value and ascending order of relative humidity. The two elements may be treated in terms of threshold values (fig. 17) or as values within certain ranges (fig. 18). While the graphs of these two types are monthly, they do allow estimates of 10-day joint probabilities, since the first step (using fig. 12) does distinguish 10-day periods. For this step, the dry bulb frequency may, alternatively, be obtained from an "F-A" graph (fig. 13). The starting point would then be the 10-day average dry bulb (as from fig. 10).

The graph operation, with alternate first step, is illustrated in figures 19 and 20. These reproduce in simpler form some of the above-mentioned figures. As an example, using figure 19, we may seek the probability of a midafternoon dry bulb (DB) ≥ 80° F (27° C) combined with a relative humidity (RH) ≤ 20 percent during August 11–20 at the canyon location in figure 10. The latter figure shows the 10-day average DB to be about 78.0° F (25.5° C). Entering panel A, figure 19, at this value, the frequency of a DB ≥ 80° F is found, following the projected lines and arrows, to be 53 percent. In this case, the same result could have been obtained directly from a frequency graph of the type shown in figure 12.

Panel B, figure 19, is then entered at the 80° F threshold; as shown by the projected lines, the probability of an accompanying RH ≤ 20 percent is 49 percent. The joint probability of these DB and RH values is thus the multiplication product of 53 percent and 49 percent, divided by 100 percent; this gives 26 percent.

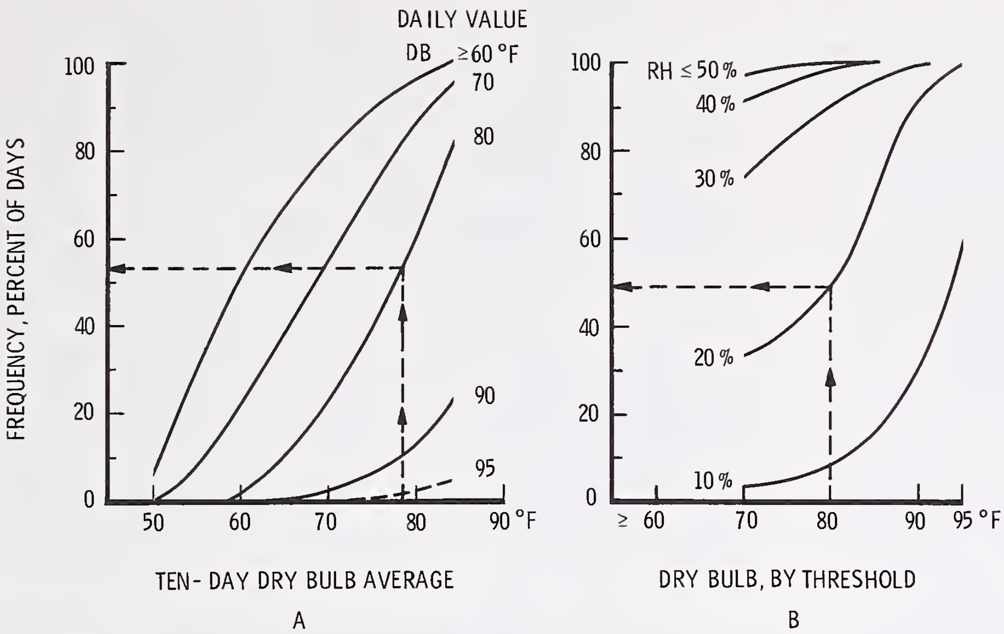


Figure 19.—Illustration of steps in graph estimation of joint frequency of specified dry bulb (DB) and relative humidity (RH) threshold values. First step uses panel A (similar to fig. 13) to obtain frequency of DB. Second step uses panel B (similar to fig. 17) to obtain frequency of RH. Result, in percent, is multiplication product of these two frequencies divided by 100 percent.

As an example using figure 20, the desired conditions may be midafternoon DB between 60° and 79° F (15.5° and 26° C) and RH between 31 and 40 percent during August 21–31 at the ridge elevation in figure 10. To find the probabilities from figure 20, the percentage-frequency interval between limiting curves is used. This particular calculation is done in two segments to correspond with the DB class intervals in panel B.

Thus entering panel A, figure 20, at an average DB of 69° F (20.5° C) (from fig. 10), the projected lines show that the probability of a DB within the 60° to 69° F range is 30 percent—this is the difference between the probabilities of ≥60° F and ≥70° F, which are, respectively, 81 percent and 51 percent. In a like manner, the probability of 70° to 79° F is found to be 39 percent (51 percent minus 12 percent).

As shown by the projected lines in panel B, figure 20, the probabilities of an accompanying RH between 31 and 40 percent (or between ≤30 and ≤40 percent) are 32 percent (42 percent minus 10 percent) for 60° to 69° F and 38 percent (90 percent minus 52 percent) for 70° to 79° F. The estimated joint probability is, therefore, [(30 × 32) + (39 × 38)], divided by 100, or 24 percent.

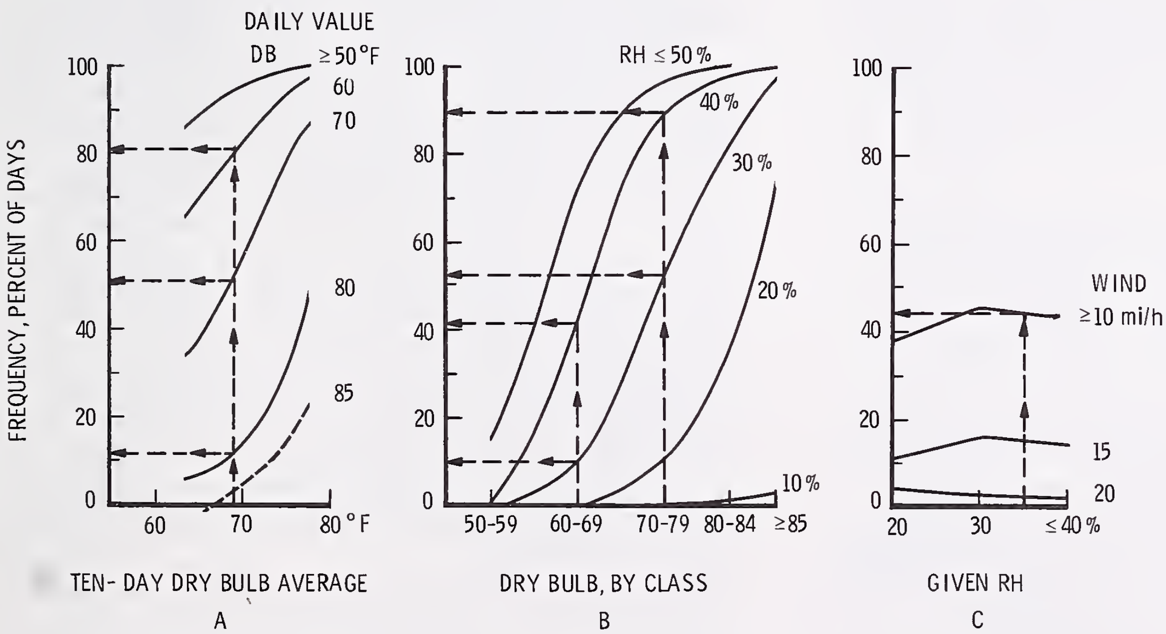


Figure 20.—Illustration of steps in graph estimation of joint frequency of dry bulb (DB) and relative humidity (RH) values within specified ranges; also for three-way frequency including windspeed. Procedure is analagous to that in figure 19, except panel B is similar to figure 18; panel C gives frequency of specified windspeeds.

Temperature, Relative Humidity, and Windspeed

The three-way probability may be estimated by multiplying the joint DB-RH probability by that for windspeed alone (as from fig. 16), then dividing by 100 percent. This simplification is valid where there is little correlation of the windspeed frequencies with DB and RH (as is found in the Northern Rockies).

Where there may be some correlation with RH (but little, if any, with DB), a graph is added as in panel C, figure 20. This plots the frequency of days with various windspeeds against given values of relative humidity. The windspeed probability obtained from such a graph is then multiplied by the DB-RH probability.

Panel C (which actually appears unnecessary in this case) indicates that for RH between 31 and 40 percent, the frequency of a windspeed ≥ 10 mi/h (16 km/h) is 44 percent. Thus, if a speed of < 10 mi/h is desired on the ridge (fig. 10), together with the previously specified DB and RH ranges, the three-way probability is the previously obtained 24 percent multiplied by 56 percent, divided by 100 percent. This gives a result of 13 percent.

SUNSHINE; SOLAR RADIATION

Sunshine Duration

Units, number of hours or percentage of maximum possible hours. The sunshine data are from first-order (now mostly airport) stations and have been summarized in NOAA (1971). Approximations for other locales can be made from maps in ESSA (1968). These maps attempt some adjustment in mountain areas, where less sunshine may be implied from generally greater cloudiness and precipitation.

Average number of hours, monthly and annual.—This type of data gives a direct measure of sunshine duration. The monthly aggregate will depend on length of daylight—varying with season and latitude, as well as cloudiness. Durations will be reduced in valley and canyon locations having shading by nearby terrain.

Average percentage of maximum possible hours.—These data are more widely published than the number of hours. The percentage values give a less direct measure of sunshine duration; but, since they do not depend on length of daylight, they more readily depict a month's generally clear or cloudy character.

Incoming Radiation

Units (of published data), langleys, defined as gram-calories per square centimeter. This is the solar radiation received at a surface location. It includes direct and diffuse (or scattered) radiation (Schroeder and Buck 1970). For conversion to units of watt-hours per square meter, the numbers of langleys are multiplied by 0.0861.

Average daily total, by months.—The published data refer to the radiation upon a horizontal surface and are from a limited number of stations, mostly at airports and agricultural experiment stations. (Publication, in "Climatological Data, National Summary" ceased in 1977.) As with sunshine duration, approximations for other locales are afforded by maps in ESSA (1968). Another set of maps, shown in part by Bryson and Hare (1974), includes radiation data estimated from relationships with observed sunshine or cloud cover and station elevation; the resulting depiction for Pacific coastal areas appears to be more realistic.

In mountain areas, radiation totals will generally increase with elevation, but other influences can be much greater—particularly in winter. Factors include slope aspect and angle (Geiger 1965; Reifsnyder and Lull 1965) and shading by terrain, as in deep valleys or canyons (Barry 1981).

POTENTIAL EVAPOTRANSPIRATION

Units, inches, or millimeters. Potential evapotranspiration (PET), from soil and vegetation surfaces, is the combined evaporation and transpiration possible when there is an adequate moisture supply at all times. Actual evapotranspiration during the year (or warm season) will generally be less. Calculated monthly values of these two quantities, together with other data pertaining to climatic water balances, are listed for many locations in the United States by Thornthwaite Associates (1964). The PET values are based on the Thornthwaite method (Oliver 1973); they may tend to be underestimated (Sellers 1965).

PET can also be calculated by use of a ratio applied to averages of data from standard, "Class A" evaporation pans. Estimates for annual and warm-season PET totals are provided by maps in ESSA (1968), based on 1946–1955 data. The ratio shown is near 0.70 in the western United States and 0.75 to 0.80 in eastern portions. Additional evaporation pan data may be obtained from U.S. Weather Bureau (1964–1965) and annual "Climatological Data," State summaries. This method is generally not reliable for estimates of average monthly PET totals.

DETAILS OF DATA CONSIDERATIONS, TREATMENT, AND ADJUSTMENT METHODS

Detection and Treatment of Errors and Missing Data; Additional Considerations

ERRORS

The published climatological data contain occasional errors or omissions (of daily precipitation amounts), aside from the designated missing data, but are in generally reliable condition.

The observations entered onto the Fire-Weather Data Library tapes at Fort Collins, Colo., undergo a screening program, which, however, has rather loose criteria. For example, dry bulb temperatures are accepted between -99° and + 136° F (-73° and + 58° C); dewpoint and minimum temperatures between -99° F and the present dry bulb (Furman and Brink 1975). Relative humidity (computed from the dry bulb and wet bulb readings) is accepted as low as 1 percent (formerly, 0 percent); windspeed as high as 99 mi/h (159 km/h); 24-hour precipitation as high as 9.99 inches (254 mm). Large errors may thus pass through the screening. Some of these errors arise in the original observations, but the majority can be traced to later processing. Errors also arise in arbitrary, fill-in values given to missing data for continuity in computing fire-danger indexes. These values commonly repeat those observed on preceding or succeeding days.

Further data screening, by the user, may thus be advisable; this has been done through 1980 at the Northern Forest Fire Laboratory for all of the Forest Service Region 1 stations. For such action, the first step is to obtain a data printout from the tapes at Fort Collins. A visual scanning can then detect highly unlikely values. Reasonable or acceptable values may vary with

the region or location, as well as portion of the fire season. The user should also examine the final output tables and statistics. Where the resources are available, the suspected errors can be confirmed and corrected by checking the original observation forms (or similar information published in monthly "Climatological Data," State summaries). Otherwise, the data can be treated as missing and estimates possibly made. Smaller, less obvious errors that escape may be tolerated, particularly if they tend to cancel one another.

MISSING DATA

Occasional days with missing data will generally have little effect on the overall statistics of elements such as temperature, relative humidity, and wind; there is a risk that extreme values will be missed. The effect can be more serious with precipitation, leading to a bias toward lower totals. A bias can also occur in temperature and humidity, as at lookout stations in the Northern Rockies. The missing data are concentrated in early and late season of usual operation, mostly in years when the lookouts are down due to cool, moist weather.

To remove these biases, estimates can be made for the daily values, or adjustments made to the 10-day or monthly averages or totals, based on comparisons with other stations. In standard climatological practice, the calculations use the "ratio method" for precipitation and the "difference method" for temperature and relative humidity, explained later.

As mentioned above, missing data may have been given fill-in values—often quite poor—for continuity in computing fire-danger indexes. When these cases are detected, as through checking data printout or original forms, the values can be replaced by more careful estimates (aided by surrounding station data) or relegated to blanks. For inclusion in the computed averages or totals, an individual 10-day period or month should have at least a specified number of observations; thus, too many blanks are to be avoided. (At the same time, erroneous data may be worse than no data at all.)

The NOAA, Environmental Data Service, computes monthly averages of daily maximum and minimum temperatures at its cooperative stations with as many as 9 days missing. These days can be consecutive or spread throughout the month; the averages will tend to be less reliable in the former case. For precipitation, prior to 1982, a monthly total was published as a blank in "Climatological Data," State summaries, when only a single daily measurement was missing. The complete monthly total was usually estimated later, in the annual issue of this publication.

In summarizing fire-weather data, the number of days required in a 10- (or 11-) day period might be set at 8 for precipitation. The rationale is that amounts on 1 or 2 missing days (as on weekends) may be included in the next day's measurement. This is not, however, true with the more recent AFFIRMS data. If possible, estimates should be made for the missing days, or 3-day totals apportioned to the individual days. The minimum acceptable number of days for temperature and relative humidity is suggested as 6 (if no estimates are made for missing days).

STATION LOCATION CHANGES

Changes in station location or exposure can adversely affect the data homogeneity and thus the comparability with past averages. This problem occurs mainly in the climatological station network, which provides year-round details. Change in daily observation time may also be serious, as discussed below. Testing of a station's record for homogeneity is a subject beyond the scope of this guide. (Methods or formulas are described by Landsberg 1958; Conrad and Pollak 1962; Oliver 1973.)

In general, when climatological data are used and there is a choice of stations, those selected should have a history of little or no change. Location and exposure changes through the mid-1950's are documented in U.S. Weather Bureau (1956–58). Less detailed documentation is given in U.S. Weather Bureau (1954–58; 1964–65). Later changes were, until 1973, listed in annual "Climatological Data," State summaries. Histories of first-order (mostly airport) stations are included in the annual issues of "Local Climatological Data." Around 1960, many of these stations underwent a change from roof to ground exposure of temperature and humidity instruments (in a change to remote, electronic equipment placed on the airfields). Their published temperature normals are adjusted to the present exposure.

OBSERVATION TIME

Differences or changes in daily observation time can be serious with respect to afternoon fire-weather data (discussed under the next heading), as well as daily maximum and minimum temperatures and the derivative monthly means. The effect on these temperatures has been described by Rumbaugh (1934); Baker (1975).

Maximum and minimum temperatures at many cooperative stations are based on a 24-hour period ending at 4 or 5 p.m. local time. This was also the case at fire-weather stations in the Northern Rockies prior to 1974. With such a dividing hour, the recorded 24-hour maximum may occasionally be 10° F (6° C) or more higher than the current day's actual maximum. The resulting monthly average maximums may be 2° F (1° C) higher than those based on the calendar day (midnight to midnight)—the 24-hour period used at the official airport stations—or on an early morning (7 or 8 a.m.) observation time, used at other cooperative stations. Such a difference occurs in the Northern Rockies in spring and summer months; about 1.0° F (0.5° C) difference in autumn and winter. Minimum temperatures read in the afternoon are generally well representative of actual overnight minimums, but may average close to 1.0° F higher than those for the calendar day. They may average 2.0° F higher in autumn and winter than minimums read in early morning.

Baker (1975) shows that monthly means based on calendar-day maximum and minimum temperatures are similar to the "true" mean obtained by averaging temperatures observed at each hour of the day. By this standard, the monthly means based on midafternoon readings can be 1.0° to 1.5° F too high during most of the year. Close comparisons should use stations having similar observation times (as listed in monthly 'Climatological Data," State summaries) or should make allowances for differing times.

Techniques for Adjusting or Extrapolating Climatic Data

ADJUSTMENT FOR CHANGE IN FIRE-WEATHER OBSERVATION TIME

A 3-hour change in fire-weather observation time, made at Forest Service Region 1 stations in 1974, has brought changes of up to 3° F (2° C) in average observed dry bulb; as much as 3 to 5 percent in average relative humidity. In such cases, for

present applications, the older, longer-based averages should be adjusted to the current observation time. Frequency distributions can then be adjusted by use of previously described frequency-versus-average graphs, which are entered at the revised average values.

For adjusting the averages, differences between the present and former observation times may be evaluated from hygrothermograph traces covering several years. Another procedure, not requiring such traces, makes a comparison with an adjacent airport station for which hourly data have been summarized. Data at the two stations are compared for several years at the former fire-weather observation time and for several years at the new time. The net change in average difference between the two stations is then added to (or subtracted from) the difference readily calculated for the airport. This method depends on there being no change in instrument exposure or accuracy at either station.

As an example of the adjustment in frequency distribution, assume that the canyon location in figure 10 has a 1300–1600 m.s.t. difference in DB averaging -3° F; RH, +3 percent. The estimated 1300 DB and RH during August 1-10 thus average 77°F (25°C) and 33 percent. Applying these averages to figures 13 and 14, respectively, the frequency of a 1300 DB $\geq$90° F (32° C) is 8 percent, compared with 12 percent at 1600 (when the average DB is 80° F [27° C]); frequency of a 1300 RH <20 percent is 20 percent, compared with 28 percent at 1600 (when the average RH is 30 percent). Combined frequencies are likewise affected.

SMOOTHING

Smoothing of 10-day averages and frequency distributions is suggested, particularly when these are based on relatively short periods of record—for example, less than 20 years for temperature and relative humidity and less than 30 years for precipitation. The smoothing seeks to reduce accidental irregularities, which are apt to be greater in a smaller data sample. The process averages in values of preceding and succeeding 10-day periods. To avoid oversmoothing, which may obscure true characteristics, weighting is used; this gives greatest weight to the central, initially calculated 10-day value. A common form of weighting applies factors of 1, 4, and 1, respectively, to three consecutive 10-day values.

To illustrate this "three-point" smoothing, we will use a 14-year record that gives the following midafternoon dry bulb averages (in °F) for successive 10- (or 11-) day periods from July 1–10 through September 1–10:

77.7, 83.5, 84.9, 82.8, 83.3, 75.4, and 73.4.

To calculate the smoothed average for August 1–10, which has an initial value of 82.8, the arithmetic is:

$[(1 \times 84.9) + (4 \times 82.8) + (1 \times 83.3)]$, divided by 6—the total number of weights.

This gives an average of 83.2. Similarly, the smoothed average for August 11–20 is calculated as 81.9; that for August 21–31, 76.3. Further examples and comments are given later in this section.

CALCULATION OF NORMALS FROM SHORT-RECORD AVERAGES

Precipitation: Ratio Method

Given: Station "X" with August rainfall average based on 13 years, 1967–79.

Adjacent stations on two (or preferably more) sides with published or available normal (1941–70 average) August rainfall, as well as averages based on 1967–79. These stations, climatological or fire-weather, ideally should have undergone little or no change in site or exposure (or surroundings) during the entire period. Use of several stations tends to reduce the error that may result with any one station.

Steps: The general formula for computing the normal at station X is:

$$N_x = \frac{A_x}{n}\left(\frac{N_1}{A_1} + \frac{N_2}{A_2} + \ldots + \frac{N_n}{A_n}\right),$$

where N is the normal and A is the short-period average; subscript x refers to the short-record station; and 1, 2, ..., n refer to the individual adjacent stations (n in number).

The method assumes that the 13-year ratio A_x/A_1 is a constant that will apply for 30 years; similarly for the ratio A_x/A_2. This, because of the large variability of precipitation, is not entirely true.

To illustrate the method, using actual data from the northern Idaho area, the 13-year August average rainfall at station X was 1.51 inches (38 mm). The 13-year averages at three surrounding stations were 1.36, 1.51, and 1.54 inches; their 30-year normals, 1.05, 1.06, and 1.33 inches, respectively. The estimated normal at station X is:

$$\frac{1.51}{3} \times \left(\frac{1.05}{1.36} + \frac{1.06}{1.51} + \frac{1.33}{1.54}\right), \text{ or } 1.18 \text{ inches (30 mm).}$$

If only one adjacent station had been used, the result would have been 1.17, 1.06, or 1.30 inches, depending on the station.

To obtain a more stable ratio between stations, the precipitation during the short (13-year) period might have been summed over July and August combined, instead of only over a single month, or monthly ratios smoothed. We would not, however, advise applying the ratio of annual totals (if available) to estimate normals for individual months, because the actual ratio between two stations may vary considerably with the season. For estimates of 10-day normal rainfall, using the above formula, smoothing of at least the 10-day averages or ratios is advisable.

Temperature and Relative Humidity: Difference Method

Given: Station "X" with August average daily maximum temperatures based on 7 years, 1967–73.

Adjacent stations, as described for precipitation, with available normal (1941–70) August average daily maximums, as well as averages based on 1967–73.

Steps: The general formula for computing the normal at station X is:

$$N_x = A_x + \frac{1}{n}\,[(N_1 - A_1) + (N_2 - A_2) + \ldots + (N_n - A_n)].$$

where notation is the same as before.

The method assumes that the 7-year differences $A_x - A_1$, $A_x - A_2$, etc., are constants that will apply for 30 years.

To illustrate the method, again using data from the northern Idaho area, the 7-year August average daily maximum at station X was 88.1° F (31.2° C). The 7-year averages at three surrounding stations were 82.5°, 85.8°, and 92.0° F; their 30-year normals, 79.5°, 82.3°, and 88.8° F, respectively. The estimated normal at station X is:

$$88.1 + \frac{1}{3}\left[(79.5-82.5)+(82.3-85.8)+(88.8-92.0)\right],$$

or 84.9° F (29.4° C).

If only one adjacent station had been used, the result would have been 85.2°, 84.6°, or 84.9° F, depending on the station. In this case, one may have sufficed.

ALTERNATE METHOD OF ADJUSTING AVERAGES AT A LOOKOUT STATION

As indicated earlier, lookouts tend to be manned for a shorter season in years when the fire danger is down. Thus, in the Northern Rocky Mountain area early July and late August data will often be missing. A nominal 1954–70 record at Williams Peak Lookout (appendix), contains 17 years of July 21–31 data, but only 6 usable years for July 1–10.

Without adjustment, the resulting climatic averages typically are biased toward warmer and drier conditions. Correct application of the adjustment methods just described uses ratios and differences based only on the specific years and days with data at all stations involved. The procedure can be laborious and the results still subject to error. The following, somewhat simpler method of adjustment may suffice. It still does require comparison with an adjacent station.

Temperature and Relative Humidity

Example for Williams Peak Lookout, Mont.

Given: 10-day average dry bulb temperature and relative humidity at 1600 m.s.t. at Williams Peak Lookout, July and August 1954–70; based on incomplete record, particularly for July 1-10 and August 21-31.

10-day average DB and RH at Ninemile Ranger Station (18 mi [30 km] east-northeast of Williams Peak) for same period as above; data complete.

Procedure: The step numbers correspond to the column numbers in table 2.

(1) and (2). Tabulate the 10- (or 11-) day average DB at Williams Peak and Ninemile, respectively.

(3). Subtract the column 2 averages from the column 1 averages. Smooth the differences in column 3 as follows (steps 4, 5, and 6):

Table 2.—Steps (described in text) for adjusting 10- (or 11-) day averages of afternoon temperature and relative humidity at a lookout station having incomplete data in early and late season; example for Williams Peak, using data from Ninemile Ranger Station (1954–1970)

Data period	Observed average: W.Pk. (1)	Observed average: Nmi. (2)	Observed average: Diff., col. 1 - col. 2 (3)	Smoothed difference: 3-period avg. (4)	Smoothed difference: 2-period avg. (5)	Assumed diff., end periods (6)	Cols. 4,5,6 (7)	W. Pk. adjusted avg., col. 2 + col. 7 (8)	W. Pk. monthly avg., from col. 8 (9)	W. Pk. avg., using elaborate method (10)
Dry bulb temperature, °F										
10 days beginning:										
July 1	70.1	78.4	− 8.3			− 10.1	− 10.1	68.3		68.2
11	73.2	82.8	− 9.6		− 10.1		− 10.1	72.7		72.4
21	73.9	84.4	− 10.5	− 10.2			− 10.2	74.2		74.0
Aug 1	72.3	82.9	− 10.6	− 10.3			− 10.3	72.6		72.3
11	72.5	82.3	− 9.8		− 10.2		− 10.2	72.1		71.8
21	68.0	76.5	− 8.5			− 10.2	− 10.2	66.3		66.1
Month:										
July	73.0	81.9							71.8	71.6
Aug	71.2	80.4							70.2	69.9
Relative humidity, percent										
July 1	39.0	35.5	+ 3.5			+ 8.7	+ 8.7	44.2		42.2
11	37.9	31.0	+ 6.9		+ 8.7		+ 8.7	39.7		38.2
21	35.0	24.5	+ 10.5	+ 9.3			+ 9.3	33.8		33.1
Aug 1	37.1	26.7	+ 10.4	+ 10.2			+ 10.2	36.9		36.6
11	36.1	26.4	+ 9.7		+ 10.1		+ 10.1	36.5		36.8
21	40.7	33.3	+ 7.4			+ 10.1	+ 10.1	43.4		43.5
Month:										
July	37.0	30.1							39.1	37.7
Aug	38.2	28.9							39.1	39.1

(4). For the two central 10- (or 11-) day periods, July 21–31 and August 1–10, calculate average differences that include the immediately preceding and succeeding 10-day periods; equal weighting is used. Thus, in table 2 we have summed the July 11–20 (column 3) difference (-9.6), the July 21–31 difference (-10.5), and the August 1–10 difference (-10.6); then divided by 3, giving -10.2 in column 4 opposite July 21- 31. For August 1–10, the arithmetic starts with the July 21–31 difference.

(5). For July 11–20 and August 11–20, the smoothing omits July 1–10 and August 21–31, respectively (the two end periods with much missing data at Williams Peak). Thus, in table 2 only the July 21–31 (column 3) difference (-10.5) is added to the July 11–20 difference (-9.6); the sum is divided by 2, giving -10.1 in column 5 opposite July 11–20.

(6). For the two end periods, July 1–10 and August 21–31, disregard the differences in column 3. Instead, use the July 11–20 and August 11–20 values, respectively, which were calculated in step 5; that is, -10.1 and -10.2.[6]

(7). Combine the smoothed differences (columns 4, 5, and 6) into one column.

(8). Add the values in column 7 to the averages at Ninemile (column 2). We now have the adjusted averages for Williams Peak.

(9). Calculate the monthly averages as follows: Multiply the adjusted averages for each of the two 10-day periods by 10 and that of the 11-day (final) period by 11; obtain sum and divide by 31.

The 10-day and monthly averages adjusted by the more elaborate difference method are shown for comparison in column 10. It is not certain which set of averages is more correct.

This procedure is suitable also for maximum temperature, but not for minimum temperature. Lookout-ranger station differences in 10-day average minimum can show larger variation during the course of the fire season, with nighttime inversions less frequent during the cloudier, wetter portions. Also diurnal temperature ranges are smaller with the cloudy, moist weather. Thus, for adjusting the early- and late-season minimums at a lookout, a compromise solution might be to subtract one-half the amount that was subtracted from the corresponding average maximum or dry bulb (column 1 minus column 8 value).

Repeat the above steps for relative humidity; illustration is given in table 2, lower half.

Precipitation

A similar procedure may be used, calculating ratios instead of differences. The ratios of lookout/ranger station average precipitation for July 1–10 and August 21–31 are then assumed equal to the smoothed ratios obtained for July 11–20 and August 11–20, respectively. The lookout averages or normals should generally be higher than those in the adjacent valleys or canyons, though differences in summer may be small. For example, the lookout/ranger station ratios for July and August as a whole are mostly between 110 percent and 140 percent in the Northern Rocky Mountain area.

[6]Use of these values is more in line with indications given by five former year-round mountaintop or pass stations in the Northern Rockies-interior Northwest. Differences in monthly average maximum temperatures between these stations and adjacent valley stations in June are practically the same as or slightly greater than those in July (contrary to the trend in column 3, table 2); similarly for differences in September compared with those in August.

In applying the adjustment methods to lookouts in areas having a longer observation season, the smoothing of differences or ratios is the same in principle as that illustrated for July and August. The end periods (with much missing data), though different, are treated as above.

EXTRAPOLATION OF FIRE-WEATHER STATISTICS AT A VALLEY OR CANYON LOCATION

The following methods apply to stations in valleys or canyons having a shortened fire-weather observation season (and short period of record). They may also be used for estimates at locations having no observational data, using only the appropriate steps. The methods extrapolate for the complete fire season, given the necessary data from preferably two adjacent valley or canyon stations. Ideally, this data should cover at least 20 recent years for temperature and relative humidity (at an unchanged daily observation time); 30 years for precipitation. With such lengths not obtainable from the fire-weather data library, smoothing is employed to reduce expected accidental irregularities. The two stations should be on opposite sides of location "X", approximately equidistant and within 25 or 50 air miles (40 or 80 km). Elevations should not differ by more than 1,000 ft (300 m); ideally, that of location "X" is somewhere in the middle.

Examples for Lolo Ranger Station, Mont.

Precipitation

Given: 10-day average rainfall at Lolo Ranger Station for July and August only, 1954–67; averages for same period at Ninemile Ranger Station, Mont., and Powell Ranger Station, Idaho (located 22 or 23 air miles [38 km] north and southwest, respectively, of Lolo Ranger Station).

Full-season (May 11-October 20) 10-day average rainfall at Ninemile and Powell for 1954–70.

Procedure: The step numbers correspond to the column numbers in table 3.

(1). Tabulate the July and August 1954–67, 10- (or 11-) day averages at Lolo Ranger Station; also, by summation, the monthly totals and the 2-month (July and August) totals.

(2) and (3). Tabulate the July and August 1954–67, 10-day averages at Ninemile and Powell, respectively.

(4). Calculate, for each period, the arithmetic average of the amounts in columns 2 and 3; obtain, by summation, the monthly and 2-month average totals.

(5) and (6). Tabulate the full-season, 1954–70, 10-day average rainfall at Ninemile and Powell, respectively.

(7). Calculate, for each period, the arithmetic average of the amounts in columns 5 and 6.

(8). Smooth the column 7 averages, using a 1–4–1 weighting as described earlier. For the first and last 10-day periods (May 11–20 and October 11–20), however, the smoothed averages are obtained by only "two-point" weighting of 2–1 and 1–2, respectively.

Thus, for May 11–20 the calculation is $[(2 \times 0.670) + (1 \times 0.710)]$, divided by 3; for May 21–31, $[(1 \times 0.670) + (4 \times 0.710) + (1 \times 0.919)]$, divided by 6. Done in overlapping sequence, the next calculation, for June 1–10, gives a weighting of 4 to the 0.919 value.

(9). The column 8 averages are adjusted to correct for the mixing of 10-day and 11-day precipitation amounts in the

Table 3.—Steps (described in text) for extrapolating 10- (or 11-) day average precipitation at a ranger station having a short fire-weather observation season; example for Lolo Ranger Station, using data from Ninemile and Powell Ranger Stations

Data period	Avg. precip., 1954-1967				Avg. precip., 1954-70			Smoothed avg.		Ratio,	Adjusted avg.	
	Lolo	Nmi.	Pow.	Avg., cols. 2 & 3	Nmi.	Pow.	Avg., cols. 5 & 6	(See text)	Adj. to 10 or 11 days	col. 1 to col. 4 total, J + A	Col. 10 ratio × col. 9 avg.	Using col. 10 ratio of 0.851
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Inches											
10 days beginning:												
May 11					0.503	0.837	0.670	0.683	0.660		No adjustment required (see text)	0.56
21					.529	.890	.710	.738	.762			.65
June 1					.829	1.009	.919	.857	.842			.71
11					.668	.840	.754	.799	.799			.68
21					.645	1.075	.860	.780	.780			.66
July 1	0.526	0.503	0.610	0.557	.418	.558	.488	.523	.523			.45
11	.344	.289	.331	.310	.312	.339	.326	.331	.325			.28
21	.176	.146	.206	.176	.172	.218	.195	.234	.242			.21
Aug 1	.246	.374	.284	.329	.316	.278	.297	.286	.281			.24
11	.269	.144	.322	.233	.278	.390	.334	.379	.373			.32
21	.736	.620	.753	.687	.571	.712	.642	.567	.586			.50
Sept 1					.280	.720	.500	.589	.579			.49
11					.616	1.162	.889	.767	.767			.65
21					.364	.728	.546	.662	.662			.56
Oct 1					.559	1.237	.898	.831	.831			.71
11					.627	1.071	.849	.865	.865			.74
Month:												
July	1.046	.938	1.147	1.043								
Aug	1.251	1.138	1.359	1.249								
J + A	2.297			2.292						1.002		
Example (see text), if col. 1 values gave J + A total of 1.950:										.851		

smoothing process. For an overall correction, the value opposite May 11 in column 8 is multiplied by 0.967; the values opposite June 1, July 11, August 1, August 11, and September 1 are multiplied by 0.983; those opposite May 21, July 21, and August 21, by 1.033.

(10). Calculate the ratio of the 2-month total in column 1 to the 2-month total in column 4. If the ratio is between 0.905 and 1.095, the averages in column 9 can, arbitrarily, be used without further adjustment. If the ratio is beyond these limits (the difference in totals is 10 percent or greater), multiply each of the averages in column 9 by this ratio.

In the present example, the July and August total in column 1, namely 2.297, is practically identical to that in column 4, so no adjustment is made to the July 1–10 through August 21–31 averages in column 9. The earlier- and later-season averages in column 9 are also left as is, though errors of 10 percent or more may occur due to possible seasonal variation of the actual precipitation ratios. This seasonal variation is largely related to greater topographic effects outside the summer months; it precludes attempts to extrapolate the average precipitation at mountain locations from valley data.

If, instead, the amounts in column 1 gave a July-August total of 1.950, the column 1/column 4 ratio would be 0.851 and adjustments made. The column 9 average for each July and August period is multiplied by 0.851. The same ratio is applied to the earlier- and later-season averages in column 9, though with the risk mentioned above.

In figure 7, the estimated averages during September and October were, in fact, lowered by as much as 17 percent from those in table 3 (column 9) on the basis of additional information—the average monthly precipitation at a nearby climatological station.

Having obtained the 10-day averages, the probabilities of particular daily amounts can be approximated from the type of graph illustrated in figure 8. To construct such a graph, the observed percentage frequencies during each 10-day period are plotted against the corresponding average rainfall; these averages are based on the actual station record. The two adjacent stations, with longer records and full-season data, are included in the same graph. These will provide more points from which generalized, average curves for an area can be drawn.

Afternoon Dry Bulb and Relative Humidity

Given: 10-day average DB and RH at 1600 m.s.t. at Lolo Ranger Station for July and August, 1954–67, and for September 1-10 during 10 of these years; averages for same periods at the Ninemile and Powell Ranger Stations.

Full-season (May 11-October 20) 10-day averages of DB and RH at Ninemile and Powell for 1954–70.

Procedure, example for DB: The step numbers correspond to the column numbers in table 4.

(1) and (2). Tabulate the full-season, 1954–70, 10-day averages of DB at Ninemile and Powell, respectively.

(3), (4), and (5). Tabulate the short-season, 1954–67, 10-day averages at Ninemile, Powell, and Lolo Ranger Stations, respectively.

(6) and (7). Obtain differences between the two periods; subtract the 1954–67 averages at Ninemile and Powell from their respective 1954–70 averages.

(8). Calculate arithmetic averages of the values in columns 6 and 7.

(9). Add the differences in column 8 to the corresponding 10-day averages at Lolo Ranger Station in column 5. Resulting values are the estimated, unsmoothed 1954–70 averages at this location.

(10). Subtract the July 21-31 DB average at Ninemile in column 1 from each of the other averages in column 1.

(11) and (12). Do the same for Powell (using the averages in column 2) and for Lolo Ranger Station (using the averages in column 9).

Table 4.—Steps (described in text) for extrapolating 10- (or 11-) day averages of afternoon temperature at a station as in table 3; example for Lolo Ranger Station

Data period	Avg., 1954-1970: Nmi. (1)	Pow. (2)	Lolo (adj) col. 5 + col. 8 (9)	Difference, 10-day avg. minus July 21-31 avg.: Nmi. (10)	Pow. (11)	Lolo (12)	Avg., cols. 10 & 11 (13)	Smoothed diff. (see text) (14)	Est. avg. at Lolo., July 21-31 avg. in col. 9 + col. 14 (15)
				Dry bulb temperature, °F					
10 days beginning:									
May 11	63.0	60.9		-21.4	-21.6		-21.5	-21.5	60.0
21	65.4	63.3		-19.0	-19.2		-19.1	-19.0	62.5
June 1	68.2	66.8		-16.2	-15.7		-16.0	-16.2	65.3
11	70.0	69.8		-14.4	-12.7		-13.6	-13.7	67.8
21	72.3	70.6		-12.1	-11.9		-12.0	-11.3	70.2
July 1	78.4	77.4	75.5	- 6.0	- 5.1	- 6.0		- 6.3	75.2
11	82.7	81.7	80.0	- 1.7	- 0.8	- 1.5		- 2.0	79.5
21	84.4	82.5	81.5	0	0	0		- 0.5	81.0
Aug 1	82.9	81.4	80.1	- 1.5	- 1.1	- 1.4		- 1.4	80.1
11	82.3	80.0	78.8	- 2.1	- 2.5	- 2.7		- 3.4	78.1
21	76.5	74.2	73.4	- 7.9	- 8.3	- 8.1		- 7.6	73.9
Sept 1	74.2	72.3	71.3	-10.2	-10.2	-10.2		-11.1	70.4
11	67.5	64.0		-16.9	-18.5		-17.7	-16.9	64.6
21	65.3	61.4		-19.1	-21.1		-20.1	-20.8	60.7
Oct 1	59.1	55.1		-25.3	-27.4		-26.4	-26.2	55.3
11	54.4	50.0		-30.0	-32.5		-31.3	-31.3	50.2

Data period	Avg., 1954-1967: Nmi. (3)	Pow. (4)	Lolo (5)	Difference in average, 1954-70 and 1954-67: Col. 1-col. 3 (6)	Col. 2-col. 4 (7)	Avg., cols. 6 & 7 (8)
				Dry bulb temperature, °F		
July 1	77.7	76.3	74.6	+0.7	+1.1	+0.9
11	83.5	82.2	80.7	−0.8	−0.5	−0.7
21	84.9	82.7	81.9	−0.5	−0.2	−0.4
Aug 1	82.8	81.4	80.0	+0.1	0	+0.1
11	83.3	80.9	79.8	−1.0	−0.9	−1.0
21	75.4	72.8	72.1	+1.1	+1.4	+1.3
Sept 1 (10 yr)	74.4	72.2	71.4	−0.2	+0.1	−0.1

(13). Calculate arithmetic averages of the values in columns 10 and 11 for the 10-day periods not included in column 12.

(14). Smooth the combined column 12 and 13 values by use of 1–4–1 weighting as described earlier. For the first and last 10-day periods, however, leave the values as they are.

(15). For each 10-day period, add the corresponding difference in column 14 to the July 21–31 average at Lolo Ranger Station shown in column 9. The estimated, smoothed averages for the full season are thus obtained.

Derive the relative humidity averages in a similar manner, as illustrated in table 5.

In figure 10, the estimated September and October RH averages were lowered by as much as 4 percent, giving more weight to the Ninemile values in column 10 (table 5) than to those at Powell in column 11, which appear less representative in late season. (This was based on further comparison with another station.)

If the 10-day averages are to be estimated for a location having no past data, only the above steps (columns) 1 and 2 are used. A third step calculates an arithmetic average of the column 1 and 2 values. A fourth step smooths these averages, using 1–4–1 weighting as in the above step 14. The resulting estimates may require adjustment for elevation differences (which generally should not exceed 1,000 ft [300 m]). As an overall rule, for each 300-foot difference from the average elevation of the two adjacent stations, add or subtract 1.0° F for DB (assuming a higher value at the lower elevation) and 1 percent for RH (assuming a higher value at the higher elevation).

Having obtained the 10-day DB and RH averages, the probabilities of particular daily readings can be approximated from the types of graph illustrated in figures 13 and 14.

Table 5.—Steps, as in table 4, for extrapolating afternoon relative humitity; example for Lolo Ranger Station

Data period	Avg.,1954-1970 Nmi. (1)	Avg.,1954-1970 Pow. (2)	Avg.,1954-1970 Lolo (adj) col. 5 + col. 8 (9)	Difference, 10-day avg. minus July 21-31 avg. Nmi. (10)	Difference, 10-day avg. minus July 21-31 avg. Pow. (11)	Difference, 10-day avg. minus July 21-31 avg. Lolo (12)	Difference, 10-day avg. minus July 21-31 avg. Avg., cols. 10 & 11 (13)	Smoothed diff. (see text) (14)	Est. avg. at Lolo., July 21-31 avg. in col. 9 + col. 14 (15)
	Relative humidity, percent								
10 days beginning:									
May 11	45.0	44.9		+20.4	+17.1		+18.8	+18.8	46.5
21	46.3	46.8		+21.7	+19.0		+20.4	+20.3	48.0
June 1	47.3	47.2		+22.7	+19.4		+21.1	+20.8	48.5
11	48.6	43.4		+24.0	+15.6		+19.8	+19.4	47.1
21	42.1	42.3		+17.5	+14.5		+16.0	+15.5	43.2
July 1	35.4	34.9	36.9	+10.8	+ 7.1	+ 9.2		+ 9.7	37.4
11	31.0	31.0	32.9	+ 6.4	+ 3.2	+ 5.2		+ 5.0	32.7
21	24.6	27.8	27.7	0	0	0		+ 1.3	29.0
Aug 1	26.7	30.4	30.3	+ 2.1	+ 2.6	+ 2.6		+ 2.2	29.9
11	26.4	30.5	30.3	+ 1.8	+ 2.7	+ 2.6		+ 3.7	31.4
21	33.3	39.1	36.7	+ 8.7	+11.3	+ 9.0		+ 8.0	35.7
Sept 1	32.9	38.4	36.9	+ 8.3	+10.6	+ 9.2		+11.0	38.7
11	42.0	50.9		+17.4	+23.1		+20.3	+18.7	46.4
21	41.6	54.8		+17.0	+27.0		+22.0	+23.3	51.0
Oct 1	49.5	65.4		+24.9	+37.6		+31.3	+30.8	58.5
11	54.6	72.4		+30.0	+44.6		+37.3	+37.3	65.0

Data period	Avg.,1954-1967 Nmi. (3)	Avg.,1954-1967 Pow. (4)	Avg.,1954-1967 Lolo (5)	Difference in average, 1954-70 and 1954-67 Col. 1-col. 3 (6)	Difference in average, 1954-70 and 1954-67 Col. 2-col. 4 (7)	Difference in average, 1954-70 and 1954-67 Avg., cols. 6 & 7 (8)
	Relative humidity, percent					
July 1	36.4	36.7	38.3	−1.0	−1.8	−1.4
11	31.3	31.2	33.2	−0.3	−0.2	−0.3
21	24.7	28.1	27.9	−0.1	−0.3	−0.2
Aug 1	27.5	30.4	30.7	−0.8	0	−0.4
11	25.4	29.1	29.1	+1.0	+1.4	+1.2
21	35.5	41.4	39.0	−2.2	−2.3	−2.3
Sept 1 (10 yr)	31.1	36.5	35.0	+1.8	+1.9	+1.9

CONCLUSION

An area's climate can be described using the outline and methods contained in this guide. For many purposes in forest and rangeland management and research, fire-weather records may provide an adequate data base. Such records back to the 1950's or 1960's, together with programs for summarizing the data (Bradshaw 1981), are available through offices having access to the USDA computer at Fort Collins, Colo. The summary tables include averages and frequency distributions. Where further detail and year-round information are needed, climatic data can be obtained from various publications that are identified.

Potential problems in using the acquired data have been discussed. These pertain to lengths of record, errors, missing data, and changes in station site and observation time. For climatic statistics, particularly with 10-day resolution, at least 15 to 20 years of data are desirable; smoothing, as illustrated, can be used to reduce accidental irregularities. A station record of 30 years (the standard "normal" period) is recommended for precipitation. Methods have been presented for adjusting averages and frequencies (or probabilities) that are based on short records.

The various climatic elements or items have been listed and discussed. Some details and examples are given as to their presentation (in tables, graphs, and maps), together with interpretative comments; these may help toward making extrapolations or inferences about numerical values at other locations or times of day.

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APPENDIX
Examples of Computer Output, Tables 6 through 14

P R E C I P I T A T I O N BY 10 (OR 11)-DAY AND MONTHLY PERIODS

STATION NUMBER 241507 NINEMILE RS YRS 1954-1970

PERIOD BEGINS	NO. YRS	MEAN TOTAL	10-DAY AND MONTHLY TOTALS STD DEV	MEDIAN	HIGHEST TOT, YR	LOWEST TOT, YR	I	MAXIMUM DAILY TOTALS EXTREME YR	AVG MAX	STD DEV	MEDIAN
MAY 11	16	.503	.442	.415	1.40 57	0.00 66	I	.83 59	.335	.271	.315
MAY 21	16	.529	.383	.475	1.39 61	.02 63	I	1.00 61	.326	.229	.285
JUN 1	17	.829	.647	.890	2.19 64	0.00 69	I	1.00 64	.401	.310	.320
JUN 11	17	.668	.443	.570	1.95 65	.13 59	I	1.29 65	.389	.277	.360
JUN 21	17	.645	.946	.570	4.04 69	0.00 61	I	1.60 69	.336	.415	.250
JUL 1	17	.418	.375	.450	1.05 56	0.00 70	I	.87 56	.275	.266	.210
JUL 11	17	.312	.442	.130	1.62 65	0.00 61	I	1.47 65	.260	.391	.100
JUL 21	17	.172	.226	.130	.89 70	0.00 69	I	.47 70	.135	.154	.080
AUG 1	17	.314	.460	.060	1.44 63	0.00 69	I	1.44 63	.242	.389	.060
AUG 11	17	.278	.639	.030	2.65 68	0.00 70	I	1.20 68	.166	.299	.030
AUG 21	17	.571	.498	.390	1.63 65	0.00 69	I	1.10 66	.350	.315	.250
SEP 1	17	.280	.289	.300	.80 61	0.00 69	I	.44 65	.192	.194	.220
SEP 11	17	.616	.573	.380	1.89 68	.01 56	I	1.00 65	.356	.287	.280
SEP 21	17	.364	.352	.270	1.42 59	0.00 57	I	.78 59	.249	.217	.240
OCT 1	15	.559	.295	.570	.98 62	.01 56	I	.70 66	.325	.189	.300
OCT 11	13	.627	.524	.530	1.74 62	0.00 69	I	1.05 59	.375	.292	.390
MONTH							I				
JUN	17	2.142	.968	2.350	4.52 69	.54 61	I	1.60 69	.688	.380	.630
JUL	17	.902	.803	.850	2.93 65	.08 59	I	1.47 65	.421	.393	.340
AUG	17	1.162	.955	.850	3.50 68	0.00 55	I	1.44 63	.528	.433	.420
SEP	17	1.261	.867	.940	3.23 59	.30 66	I	1.00 65	.456	.225	.430

Table 6.—Precipitation: mean, median, and extreme totals (inches).

PRECIPITATION - PERCENT FREQUENCY OF DAILY AMOUNTS (INCHES)

- GIVEN TO NEAREST TENTH PERCENT, DECIMAL POINT OMITTED

STATION NUMBER 241507 NINEMILE RS 1954-1970

PERIOD BEGINS	TOTAL NUM. DAYS	TR	≥ .01	≥ .05	≥ .10	≥ .20	≥ .30	≥ .40	≥ .50	≥ .60	≥ .80	≥1.00	≥1.50	≥2.00	≥3.00	≥4.00
MAY 11	159	157	277	201	145	75	57	50	44	19	6					
MAY 21	179	140	324	229	179	101	56	28	11	11	6	6				
JUN 1	170	59	400	288	206	141	106	71	53	35	18	5				
JUN 11	170	112	347	259	194	135	76	41	18	12	6	5				
JUN 21	170	100	347	235	165	112	47	35	29	24	18	18	6			
JUL 1	170	124	247	153	112	76	47	35	18	12	6					
JUL 11	170	100	159	100	71	41	29	12	12	12	12	6				
JUL 21	187	75	118	70	53	32	21	5								
AUG 1	170	47	147	112	71	35	24	24	12	12	12	6				
AUG 11	170	94	141	112	76	53	29	18	12	6	6	6				
AUG 21	186	134	247	177	145	81	48	38	32	27	11	5				
SEP 1	170	100	153	112	88	65	35	29								
SEP 11	170	147	312	229	159	112	71	47	35	18	12	6				
SEP 21	170	124	265	159	106	59	35	24	12	6						
OCT 1	150	120	347	240	187	113	60	40	20	13						
OCT 11	130	100	346	238	169	108	85	46	38	15	8	8				
MONTH																
JUN	510	90	365	261	198	129	76	49	33	24	14	10	2			
JUL	527	99	173	106	78	49	32	17	9	8	6	2				
AUG	526	95	181	133	97	57	34	27	19	15	10	6				
SEP	510	124	243	157	118	78	47	33	16	8	4	2				

Table 7.—Precipitation: frequency distributions of daily amounts (inches)

PRECIPITATION - PERCENT FREQUENCY OF PERIOD TOTALS (INCHES)

- GIVEN TO NEAREST TENTH PERCENT, DECIMAL POINT OMITTED

STATION NUMBER 241507 NINEMILE RS 1954-1970

PERIOD BEGINS	NUM. YEARS	TR	≥ .01	≥ .05	≥ .10	≥ .20	≥ .30	≥ .40	≥ .50	≥ .60	≥ .80	≥1.00	≥1.50	≥2.00	≥3.00	≥4.00
MAY 11	16		875	813	813	688	563	500	438	438	188	188				
MAY 21	17		1000	941	941	882	705	588	529	294	235	118				
JUN 1	17		882	882	824	765	647	647	647	588	529	471	176	59		
JUN 11	17		1000	1000	1000	941	824	706	647	471	294	175	59			
JUN 21	17		941	941	765	588	588	529	529	471	118	118	59	59	59	59
JUL 1	17	59	882	824	647	529	529	529	471	353	118	118				
JUL 11	17	118	765	706	588	412	353	235	118	118	118	118	59			
JUL 21	17	118	647	529	529	294	235	59	59	59	59					
AUG 1	17	59	705	588	471	412	353	235	176	175	118	118				
AUG 11	17	176	588	471	412	353	175	176	176	118	59	59	59	59		
AUG 21	17		824	824	824	765	588	471	471	412	235	175	118			
SEP 1	17	59	647	588	529	529	529	471	235	176	59					
SEP 11	17		1000	882	882	765	647	412	412	353	294	235	118			
SEP 21	17	59	882	824	706	647	471	412	294	176	59	59				
OCT 1	15		1000	933	933	867	733	733	600	467	267					
OCT 11	13		846	846	846	769	692	615	538	385	385	231	77			
MONTH																
JUN	17		1000	1000	1000	1000	1000	1000	1000	882	882	882	765	588	59	59
JUL	17		1000	1000	824	765	647	588	588	529	529	353	235	118		
AUG	17	59	882	882	824	824	824	765	765	765	588	412	353	176	59	
SEP	17		1000	1000	1000	1000	1000	882	824	824	647	471	235	235	59	

Table 8.—Precipitation: frequency distributions of 10-day and monthly totals (inches)

D R Y   B U L B   T E M P E R A T U R E — MEAN, STANDARD DEVIATION, AND EXTREME VALUES

STATION NUMBER 241507   NINEMILE RS — 1954-1970

	10-DAY AND MONTHLY PERIOD MEANS					10-DAY AND MONTHLY EXTREMES								
PRD. BEGINS	MEAN	STD. DEV.	MEDIAN	HIGHEST AVG,YR	LOWEST AVG,YR	HIGH,YR	AVG. HIGH	STD. DEV.	MEDIAN HIGH	LOW,YR	AVG. LOW	STD. DEV.	MEDIAN LOW	PRD. BEGINS
MAY 11	63.0	5.1	62.0	72.3 54	55.7 66	86 58	76.3	5.9	76.0	41 59	48.1	5.1	49.0	MAY 11
MAY 21	65.4	7.3	65.0	81.4 58	53.6 55	90 66	75.8	7.8	78.0	41 60	52.9	8.7	51.0	MAY 21
JUN 1	68.3	5.8	66.0	77.4 70	60.8 54	90 57	79.8	6.2	82.0	48 65	56.9	6.5	55.0	JUN 1
JUN 11	70.0	6.1	69.0	82.4 61	62.2 64	94 61	84.1	6.0	84.0	44 69	56.0	6.9	55.0	JUN 11
JUN 21	72.3	6.2	71.0	82.5 61	60.1 69	96 55	84.9	5.8	85.0	50 69	58.2	7.3	55.0	JUN 21
JUL 1	78.3	6.0	79.0	88.1 68	64.2 55	95 68	89.6	4.5	91.0	55 55	64.9	6.8	62.0	JUL 1
JUL 11	82.7	5.4	81.0	94.6 60	73.3 63	102 60	92.1	4.1	92.0	56 70	70.2	9.3	70.0	JUL 11
JUL 21	84.4	3.8	85.0	90.8 60	74.9 70	99 60	92.2	3.8	91.0	57 54	71.8	7.4	74.0	JUL 21
AUG 1	82.7	4.5	84.0	90.2 61	73.9 62	102 61	92.1	3.8	92.0	58 56	69.1	7.2	68.0	AUG 1
AUG 11	82.3	5.6	83.0	94.6 67	65.4 68	98 67	91.4	3.7	91.0	53 68	69.3	10.7	68.0	AUG 11
AUG 21	76.5	7.3	74.0	87.5 67	65.8 60	98 69	89.1	6.3	90.0	53 64	63.1	8.6	62.0	AUG 21
SEP 1	74.2	7.3	73.0	87.3 55	62.2 65	97 67	85.9	6.1	85.0	42 62	59.3	8.9	58.0	SEP 1
SEP 11	67.5	7.7	68.0	78.7 56	48.3 65	91 59	81.1	8.3	85.0	36 65	52.0	8.3	53.0	SEP 11
SEP 21	65.3	8.5	63.0	78.7 67	53.7 59	90 67	76.3	8.0	76.0	42 68	51.5	8.3	49.0	SEP 21
OCT 1	59.1	6.0	59.0	67.5 55	50.2 69	79 63	71.5	6.8	73.0	38 70	47.3	6.4	46.0	OCT 1
OCT 11	54.4	4.6	54.0	64.1 63	47.8 68	76 64	64.3	6.5	62.0	35 61	44.8	4.5	46.0	OCT 11
MONTH														MONTH
JUN	70.2	3.2	69.0	79.6 61	67.1 66	96 55	88.2	3.6	87.0	44 69	52.1	3.9	52.0	JUN
JUL	81.9	3.4	81.0	90.3 60	77.5 55	102 60	94.4	3.2	94.0	55 55	62.5	6.2	61.0	JUL
AUG	80.4	5.0	80.0	89.6 67	73.9 68	102 61	94.5	3.3	94.0	53 68	61.1	7.3	62.0	AUG
SEP	69.3	6.2	69.0	79.5 67	56.5 65	97 67	86.7	5.5	88.0	36 65	46.7	6.2	44.0	SEP

R E L A T I V E   H U M I D I T Y — MEAN, STANDARD DEVIATION, AND EXTREME VALUES

STATION NUMBER 241507   NINEMILE RS — 1954-1970

	10-DAY AND MONTHLY PERIOD MEANS					10-DAY AND MONTHLY EXTREMES								
PRD. BEGINS	MEAN	STD. DEV.	MEDIAN	HIGHEST AVG,YR	LOWEST AVG,YR	HIGH,YR	AVG. HIGH	STD. DEV.	MEDIAN HIGH	LOW,YR	AVG. LOW	STD. DEV.	MEDIAN LOW	PRD. BEGINS
MAY 11	45.0	11.7	42.0	72.0 62	26.9 65	100 55	74.8	15.2	71.5	11 64	24.5	8.6	22.5	MAY 11
MAY 21	46.3	10.0	45.0	67.1 62	32.1 63	100 60	76.2	13.4	78.0	15 65	27.0	7.6	29.0	MAY 21
JUN 1	47.7	11.0	49.0	67.3 58	27.0 65	94 64	72.4	18.2	74.0	14 70	27.6	5.7	27.0	JUN 1
JUN 11	48.6	9.4	48.0	62.0 65	28.7 61	100 56	80.1	14.0	83.0	6 68	24.2	7.3	24.0	JUN 11
JUN 21	42.1	10.4	43.0	59.2 69	20.9 61	95 58	71.0	16.0	75.0	9 64	21.3	6.5	22.0	JUN 21
JUL 1	35.5	10.5	33.0	60.5 55	19.3 67	89 65	62.5	20.8	68.0	11 66	20.8	6.4	20.0	JUL 1
JUL 11	31.0	8.3	33.0	47.0 55	18.7 60	100 55	59.1	24.5	55.0	9 67	18.0	5.8	17.0	JUL 11
JUL 21	24.5	5.9	20.0	38.0 55	12.7 66	84 70	46.5	18.7	47.0	9 65	14.3	3.4	15.0	JUL 21
AUG 1	26.7	9.7	24.0	45.8 65	15.7 69	89 62	53.1	23.7	45.0	8 67	14.6	4.5	14.0	AUG 1
AUG 11	26.4	10.7	23.0	58.2 68	11.2 67	94 68	47.3	21.4	43.0	6 67	13.2	3.5	13.0	AUG 11
AUG 21	33.3	12.2	32.0	53.1 65	14.1 69	88 56	60.9	21.7	61.0	8 66	17.8	7.5	16.0	AUG 21
SEP 1	32.9	9.3	36.0	47.5 65	20.1 69	95 63	61.8	21.1	58.0	10 57	17.7	6.0	17.0	SEP 1
SEP 11	42.0	11.3	37.0	65.3 65	25.4 56	100 65	73.6	17.7	75.0	16 69	22.6	9.4	20.0	SEP 11
SEP 21	41.6	9.9	40.0	60.1 59	24.0 67	94 65	71.8	14.7	74.0	13 57	23.9	6.9	23.0	SEP 21
OCT 1	49.5	9.9	48.0	71.8 57	34.5 50	100 55	80.9	12.7	83.0	13 50	27.1	9.7	25.0	OCT 1
OCT 11	54.6	12.1	56.0	72.6 57	34.7 70	100 61	82.0	15.7	92.0	14 64	34.9	12.4	35.0	OCT 11
MONTH														MONTH
JUN	46.1	6.4	45.0	56.8 58	30.4 61	100 56	84.9	12.8	89.0	6 68	18.9	6.1	20.0	JUN
JUL	30.1	7.3	31.0	48.2 55	20.0 67	100 55	74.4	17.0	79.0	9 67	13.8	3.4	15.0	JUL
AUG	28.9	9.1	25.0	43.6 65	15.5 67	94 68	68.8	21.4	73.0	6 67	12.2	3.5	13.0	AUG
SEP	38.4	8.3	37.0	55.0 65	25.6 67	100 65	84.2	10.4	83.0	10 67	16.1	5.0	16.0	SEP

D E W   P O I N T — MEAN, STANDARD DEVIATION, AND EXTREME VALUES

STATION NUMBER 241507   NINEMILE RS — 1954-1970

	10-DAY AND MONTHLY PERIOD MEANS					10-DAY AND MONTHLY EXTREMES								
PRD. BEGINS	MEAN	STD. DEV.	MEDIAN	HIGHEST AVG,YR	LOWEST AVG,YR	HIGH,YR	AVG. HIGH	STD. DEV.	MEDIAN HIGH	LOW,YR	AVG. LOW	STD. DEV.	MEDIAN LOW	PRD. BEGINS
MAY 11	38.7	5.4	38.0	47.1 62	28.3 65	60 60	47.0	5.9	46.5	12 65	29.5	7.6	30.5	MAY 11
MAY 21	41.9	4.3	40.0	49.1 58	35.5 59	58 66	50.8	4.4	51.0	19 67	32.4	7.3	31.0	MAY 21
JUN 1	45.5	3.7	45.0	52.4 57	37.9 65	62 69	53.1	4.5	53.0	31 68	36.4	3.6	37.0	JUN 1
JUN 11	47.2	3.3	47.0	53.2 63	39.5 68	67 63	56.8	5.3	56.0	2 68	35.9	9.9	40.0	JUN 11
JUN 21	45.1	3.8	45.0	52.1 54	37.5 61	67 62	55.8	5.1	55.0	16 64	35.4	6.9	37.0	JUN 21
JUL 1	45.7	4.8	46.0	53.4 63	36.4 67	63 55	55.7	5.0	56.0	25 62	37.3	5.6	38.0	JUL 1
JUL 11	46.4	6.1	45.0	61.6 55	37.8 69	70 55	55.6	6.2	54.0	24 67	36.3	8.0	35.0	JUL 11
JUL 21	41.8	5.6	40.0	52.1 55	29.8 66	65 56	52.4	8.1	53.0	21 66	31.9	6.5	31.0	JUL 21
AUG 1	41.7	5.4	40.0	54.0 65	33.4 69	63 56	53.0	7.1	54.0	23 61	32.3	6.7	30.0	AUG 1
AUG 11	40.8	5.2	41.0	48.2 65	31.2 67	63 65	51.2	6.1	52.0	17 67	30.1	6.5	32.0	AUG 11
AUG 21	41.3	5.8	41.0	49.7 56	30.4 70	60 65	51.5	5.5	50.0	16 69	31.2	8.3	31.0	AUG 21
SEP 1	39.9	4.3	39.0	47.0 68	31.5 69	60 63	49.0	5.2	49.0	21 62	29.3	5.5	27.0	SEP 1
SEP 11	40.4	4.3	40.0	48.5 59	30.1 70	59 59	50.0	4.0	50.0	17 70	30.6	7.0	32.0	SEP 11
SEP 21	38.7	3.8	38.0	45.2 63	32.0 61	58 63	48.4	5.0	47.0	23 70	30.7	4.8	30.0	SEP 21
OCT 1	37.8	3.7	36.0	44.2 63	33.0 61	55 64	46.7	4.1	46.0	21 51	28.9	4.9	28.0	OCT 1
OCT 11	36.6	6.8	37.0	44.0 57	22.0 69	56 57	45.2	5.5	46.0	7 69	25.2	10.3	29.0	OCT 11
MONTH														MONTH
JUN	46.0	2.5	46.0	51.1 58	41.3 68	67 63	59.8	4.6	59.0	2 68	30.6	9.1	33.0	JUN
JUL	44.5	4.4	44.0	54.2 55	37.8 66	70 55	59.2	4.9	59.0	21 65	30.2	6.0	30.0	JUL
AUG	41.2	4.8	42.0	50.3 65	33.2 69	63 65	56.1	4.9	57.0	16 69	26.7	5.6	27.0	AUG
SEP	39.7	3.3	39.0	45.4 68	34.1 70	60 63	52.5	4.0	52.0	17 70	25.6	5.4	26.0	SEP

Table 9.—Dry bulb (°F), relative humidity (percent), and dewpoint (°F) at 1600 m.s.t. Note: Relative humidity listed for Williams Peak averages 1 percent too high, due to approximation in formula used to compute values

DRY BULB TEMPERATURE

MEAN, STANDARD DEVIATION, AND EXTREME VALUES

STATION NUMBER 241305 WILLIAMS PEAK

1954-1970

PRD. BEGINS	10-DAY AND MONTHLY PERIOD MEANS: MEAN	STD. DEV.	MEDIAN	HIGHEST AVG,YR	LOWEST AVG,YR	10-DAY AND MONTHLY EXTREMES: HIGH,YR	AVG. HIGH	STD. DEV.	MEDIAN HIGH	LOW,YR	AVG. LOW	STD. DEV.	MEDIAN LOW	PRD. BEGINS
JUL 1	70.1	6.5	68.0	83.8 68	61.7 58	89 68	79.2	5.5	79.0	47 57	58.2	10.8	52.5	JUL 1
JUL 11	73.2	4.9	73.0	83.4 60	65.6 63	91 60	81.6	4.4	83.0	47 70	61.9	8.7	60.0	JUL 11
JUL 21	73.9	3.1	74.0	78.1 56	68.4 70	89 68	82.6	3.3	83.0	44 54	61.4	7.5	63.0	JUL 21
AUG 1	72.3	4.6	73.0	80.5 61	64.4 62	92 61	82.2	4.0	81.0	50 62	58.2	6.4	56.0	AUG 1
AUG 11	72.5	5.8	72.0	87.1 67	64.0 59	91 67	81.9	4.7	82.0	41 64	59.6	10.6	60.0	AUG 11
AUG 21	68.0	8.0	68.5	82.6 70	54.2 60	90 69	80.9	6.1	82.0	42 60	54.2	11.8	49.0	AUG 21
MONTH														MONTH
JUL	73.0	3.2	72.0	78.5 60	67.8 58	91 60	84.3	3.4	84.0	44 54	55.3	7.4	53.0	JUL
AUG	71.2	4.9	72.0	80.7 67	62.4 60	92 61	85.3	4.1	86.0	41 64	50.8	7.4	51.0	AUG

RELATIVE HUMIDITY

MEAN, STANDARD DEVIATION, AND EXTREME VALUES

STATION NUMBER 241305 WILLIAMS PEAK

1954-1970

PRD. BEGINS	10-DAY AND MONTHLY PERIOD MEANS: MEAN	STD. DEV.	MEDIAN	HIGHEST AVG,YR	LOWEST AVG,YR	10-DAY AND MONTHLY EXTREMES: HIGH,YR	AVG. HIGH	STD. DEV.	MEDIAN HIGH	LOW,YR	AVG. LOW	STD. DEV.	MEDIAN LOW	PRD. BEGINS
JUL 1	40.0	8.9	36.5	53.2 58	30.0 60	88 56	60.4	18.0	59.5	14 57	25.9	7.5	25.5	JUL 1
JUL 11	38.9	7.0	40.0	53.8 64	23.6 60	100 64	63.9	22.3	62.0	17 60	25.1	4.7	26.0	JUL 11
JUL 21	36.0	7.4	34.0	48.6 70	22.1 66	89 65	59.4	17.6	56.0	16 66	22.5	3.5	23.0	JUL 21
AUG 1	38.1	9.1	38.0	57.6 62	25.6 59	100 65	68.5	23.0	68.0	17 69	23.6	4.7	24.0	AUG 1
AUG 11	37.1	9.5	37.0	52.7 64	21.4 70	94 59	60.7	19.4	62.0	15 70	22.2	5.5	21.0	AUG 11
AUG 21	41.7	13.7	42.0	59.8 60	16.6 70	94 56	69.4	26.1	83.0	9 70	23.6	9.9	24.0	AUG 21
MONTH														MONTH
JUL	38.0	6.5	40.0	49.5 64	26.5 66	100 64	74.1	17.4	68.0	14 57	20.4	3.4	21.0	JUL
AUG	39.2	8.8	38.0	53.6 60	25.1 67	100 65	82.1	18.0	89.0	9 70	19.4	6.0	20.0	AUG

Table 9.—(con.)

D R Y   B U L B   T E M P E R A T U R E

PERCENTAGE FREQUENCY DISTRIBUTION OF DAILY VALUES
-GIVEN TO TENTHS PERCENT, DECIMAL POINT OMITTED

STATION NUMBER 241507   NINEMILE RS   1954-1970

PRD. BEGINS	BELOW 0	0 TO 4	5 TO 9	10 TO 14	15 TO 19	20 TO 24	25 TO 29	30 TO 34	35 TO 39	40 TO 44	45 TO 49	50 TO 54	55 TO 59	60 TO 64	65 TO 69	70 TO 74	75 TO 79	80 TO 84	85 TO 89	90 TO 94	95 TO 99	100 AND ABOVE	PRD. BEGINS
MAY 11										34	74	155	135	128	162	149	95	54	14				MAY 11
MAY 21										13	31	94	182	145	145	132	151	94	5	6			MAY 21
JUN 1											6	71	147	124	188	224	124	65	47	6			JUN 1
JUN 11										6	12	53	118	159	141	129	159	135	59	29			JUN 11
JUN 21												59	94	124	129	141	135	188	100	24	6		JUN 21
JUL 1													53	65	88	153	112	176	229	118	6		JUL 1
JUL 11													6	35	24	112	141	218	229	176	53	6	JUL 11
JUL 21													11	5	32	53	86	241	348	187	37		JUL 21
AUG 1													6	35	53	65	112	224	288	182	29	6	AUG 1
AUG 11												12	35	18	59	41	124	182	312	171	47		AUG 11
AUG 21												20	66	77	107	128	158	163	148	92	41		AUG 21
SEP 1										6		50	44	139	117	133	128	155	144	72	11		SEP 1
SEP 11									6	40	17	69	145	127	92	145	145	145	64	6			SEP 11
SEP 21										37	93	93	99	142	123	136	136	117	19	6			SEP 21
OCT 1									8	92	123	154	162	138	123	100	100						OCT 1
OCT 11									9	85	222	256	197	85	85	51	9						OCT 11

MONTH	BELOW 0	0 TO 4	5 TO 9	10 TO 14	15 TO 19	20 TO 24	25 TO 29	30 TO 34	35 TO 39	40 TO 44	45 TO 49	50 TO 54	55 TO 59	60 TO 64	65 TO 69	70 TO 74	75 TO 79	80 TO 84	85 TO 89	90 TO 94	95 TO 99	100 AND ABOVE	MONTH
JUN										2	6	61	120	135	153	165	139	129	69	20	2		JUN
JUL													23	34	47	104	112	213	271	161	32	2	JUL
AUG												11	37	45	75	80	132	188	244	146	39	2	AUG
SEP									2	27	35	70	95	136	111	138	136	140	78	29	4		SEP

R E L A T I V E   H U M I D I T Y

PERCENTAGE FREQUENCY DISTRIBUTION OF DAILY VALUES
-GIVEN TO TENTHS PERCENT, DECIMAL POINT OMITTED

STATION NUMBER 241507   NINEMILE RS   1954-1970

PRD. BEGINS	BELOW 0	0 TO 4	5 TO 9	10 TO 14	15 TO 19	20 TO 24	25 TO 29	30 TO 34	35 TO 39	40 TO 44	45 TO 49	50 TO 54	55 TO 59	60 TO 64	65 TO 69	70 TO 74	75 TO 79	80 TO 84	85 TO 89	90 TO 94	95 TO 99	100 AND ABOVE	PRD. BEGINS
MAY 11				14	14	95	182	108	68	108	68	61	61	27	68	34	14	7	34	34		7	MAY 11
MAY 21					44	63	75	164	113	126	57	57	57	57	38	38	50	38	13	6		5	MAY 21
JUN 1				6		53	124	129	94	76	100	88	71	65	53	53	12	35	24	18			JUN 1
JUN 11			6	6	12	55	65	176	71	65	82	88	76	59	53	53	53	24	18	12		18	JUN 11
JUN 21			6	6	71	100	135	141	53	100	94	65	35	24	59	24	47	12	24		6		JUN 21
JUL 1				24	129	200	135	112	100	59	59	29	41	6	29		41	29	6				JUL 1
JUL 11			6	29	153	235	153	135	88	71	35	24	12	12	6	6	12	6	12			6	JUL 11
JUL 21			11	107	321	209	112	96	43	32	16	11	27		5	5		5					JUL 21
AUG 1			12	135	229	235	82	112	82	12	18	18		6	12	18	6	12	12				AUG 1
AUG 11			29	147	247	147	135	118	47	29	29	12		12	12	12			18	6			AUG 11
AUG 21			26	92	184	117	97	97	56	82	46	56	31	46	20	10	10	15	15				AUG 21
SEP 1				56	200	150	139	128	72	56	50	50	22	17	11	11	11	17		6	6		SEP 1
SEP 11					75	121	179	156	69	29	92	46	40	40	29	35	29	23	12	12		12	SEP 11
SEP 21				6	43	160	93	142	86	123	68	25	80	37	49	6	6	31	37	6			SEP 21
OCT 1				8	31	46	69	100	108	100	100	77	69	38	54	31	54	23	46	38		8	OCT 1
OCT 11				9	17	17	43	60	137	94	103	60	68	85	94	51	26	17	60	51		9	OCT 11

MONTH	BELOW 0	0 TO 4	5 TO 9	10 TO 14	15 TO 19	20 TO 24	25 TO 29	30 TO 34	35 TO 39	40 TO 44	45 TO 49	50 TO 54	55 TO 59	60 TO 64	65 TO 69	70 TO 74	75 TO 79	80 TO 84	85 TO 89	90 TO 94	95 TO 99	100 AND ABOVE	MONTH
JUN			4	6	27	73	108	149	73	80	92	80	61	49	55	43	37	24	22	10	2	6	JUN
JUL			5	55	205	214	133	114	76	53	35	21	27	6	13	4	17	13	5			2	JUL
AUG			22	123	218	164	104	108	62	43	32	30	11	22	15	13	6	9	15	2			AUG
SEP				21	109	144	138	142	76	68	70	41	47	31	29	17	16	23	15	8	2	4	SEP

Table 10.—Dry bulb temperature (°F) and relative humidity (percent): frequency distributions

MAXIMUM TEMPERATURE — MEAN, STANDARD DEVIATION, AND EXTREME VALUES

STATION NUMBER 241507 NINEMILE RS — 1954-1970

PRD. BEGINS	10-DAY AND MONTHLY PERIOD MEANS: MEAN	STD. DEV.	MEDIAN	HIGHEST AVG, YR	LOWEST AVG, YR	10-DAY AND MONTHLY EXTREMES: HIGH, YR	AVG. HIGH	STD. DEV.	MEDIAN HIGH	LOW, YR	AVG. LOW	STD. DEV.	MEDIAN LOW	PRD. BEGINS
MAY 11	68.1	5.3	66.0	77.0 64	57.8 66	95 65	80.5	7.4	79.5	45 58	54.8	6.2	55.0	MAY 11
MAY 21	70.7	7.0	69.0	85.4 58	61.3 55	90 66	81.1	6.3	82.0	46 57	58.5	8.6	58.0	MAY 21
JUN 1	74.1	5.3	72.0	82.2 70	67.8 66	94 57	83.1	6.1	84.0	52 66	63.4	6.5	61.0	JUN 1
JUN 11	75.5	6.0	74.0	88.4 61	67.4 70	102 65	87.5	6.3	86.0	54 56	62.3	6.5	61.0	JUN 11
JUN 21	78.6	6.5	81.0	87.9 61	63.4 69	98 55	87.9	5.9	88.0	53 69	64.7	7.2	62.0	JUN 21
JUL 1	83.9	5.7	85.0	89.8 68	69.6 55	97 63	92.4	4.1	94.0	60 55	73.3	6.8	73.0	JUL 1
JUL 11	88.0	5.4	88.0	99.4 60	78.5 63	105 60	95.5	4.4	95.0	63 63	78.6	7.5	77.0	JUL 11
JUL 21	89.5	3.7	88.0	96.6 60	82.3 70	103 60	95.5	3.4	94.0	74 70	81.4	5.0	82.0	JUL 21
AUG 1	88.9	4.0	88.0	97.8 61	81.6 62	106 61	96.1	4.0	96.0	66 64	78.5	6.4	80.0	AUG 1
AUG 11	87.9	6.0	88.0	99.9 67	71.3 68	102 67	94.8	4.1	94.0	59 68	78.8	9.7	80.0	AUG 11
AUG 21	82.3	6.8	80.0	94.1 67	73.4 60	102 66	92.8	6.1	94.0	62 65	71.6	8.4	71.0	AUG 21
SEP 1	79.6	7.4	79.0	93.3 55	68.1 64	102 67	88.9	6.5	89.0	54 65	67.1	8.5	65.0	SEP 1
SEP 11	73.7	7.9	75.0	84.3 56	54.0 65	95 59	85.1	8.6	87.0	42 65	60.8	11.2	60.0	SEP 11
SEP 21	70.5	9.1	68.0	88.4 67	59.2 61	94 67	79.2	9.7	79.0	44 61	57.7	10.5	54.0	SEP 21
OCT 1	64.5	6.3	64.0	73.5 60	53.9 69	92 57	76.3	8.6	77.0	40 70	52.1	7.5	50.0	OCT 1
OCT 11	59.5	6.0	60.0	68.2 63	49.3 69	77 64	67.9	7.3	70.0	41 69	49.2	4.3	49.0	OCT 11
MONTH														MONTH
JUN	76.1	3.2	75.0	86.1 61	71.5 66	102 65	92.1	4.2	91.0	52 66	58.8	5.2	58.0	JUN
JUL	87.2	3.5	86.0	95.1 60	82.4 69	105 60	97.2	3.5	97.0	60 55	71.8	6.9	73.0	JUL
AUG	86.3	4.6	85.5	95.7 67	77.9 68	106 61	97.9	3.2	97.0	59 68	70.6	7.9	71.0	AUG
SEP	74.8	6.6	75.0	87.5 67	62.3 65	102 67	89.7	6.2	90.0	42 65	54.2	9.0	52.0	SEP

MINIMUM TEMPERATURE — MEAN, STANDARD DEVIATION, AND EXTREME VALUES

STATION NUMBER 241507 NINEMILE RS — 1954-1970

PRD. BEGINS	10-DAY AND MONTHLY PERIOD MEANS: MEAN	STD. DEV.	MEDIAN	HIGHEST AVG, YR	LOWEST AVG, YR	10-DAY AND MONTHLY EXTREMES: HIGH, YR	AVG. HIGH	STD. DEV.	MEDIAN HIGH	LOW, YR	AVG. LOW	STD. DEV.	MEDIAN LOW	PRD. BEGINS
MAY 11	34.7	3.2	34.0	40.4 57	28.3 66	57 62	43.4	5.6	43.0	20 66	26.6	3.5	27.0	MAY 11
MAY 21	36.8	3.2	36.0	46.8 59	33.8 59	53 55	44.7	3.9	43.0	22 66	28.9	4.9	28.0	MAY 21
JUN 1	40.2	3.7	41.0	45.7 57	32.4 62	52 68	47.0	4.4	47.0	27 62	33.8	3.3	34.0	JUN 1
JUN 11	41.7	2.2	41.0	47.0 59	38.0 69	62 54	49.6	4.1	49.0	28 54	33.8	3.6	34.0	JUN 11
JUN 21	40.8	3.4	40.0	49.1 70	36.0 56	60 70	50.4	5.8	48.0	27 64	32.6	3.1	33.0	JUN 21
JUL 1	43.4	2.9	43.0	50.3 64	38.9 59	69 64	52.9	5.8	52.0	29 62	35.4	2.7	35.0	JUL 1
JUL 11	45.6	2.8	45.0	51.1 55	40.9 63	66 62	54.9	5.0	54.0	31 62	38.5	4.4	39.0	JUL 11
JUL 21	43.8	3.4	43.0	49.3 55	36.3 63	67 62	54.1	6.4	55.0	31 59	36.4	3.6	36.0	JUL 21
AUG 1	43.3	2.1	42.5	47.4 60	39.7 69	59 70	52.0	4.0	50.5	32 69	36.4	2.8	36.0	AUG 1
AUG 11	42.4	2.8	41.0	46.8 68	37.1 64	59 65	51.3	5.4	51.0	31 54	35.3	2.4	36.0	AUG 11
AUG 21	41.6	3.6	41.0	48.2 65	35.8 62	65 65	51.5	6.9	51.0	26 65	32.6	3.5	32.0	AUG 21
SEP 1	38.1	4.1	38.0	45.6 63	28.8 62	59 67	48.3	6.0	49.0	21 62	28.9	4.4	28.0	SEP 1
SEP 11	36.6	5.2	36.0	46.0 59	27.3 64	55 59	46.8	5.0	47.0	16 70	27.5	7.0	28.0	SEP 11
SEP 21	34.3	3.7	34.0	40.2 69	27.8 70	48 63	43.5	2.5	43.0	18 64	26.4	4.6	27.0	SEP 21
OCT 1	31.4	3.5	30.0	37.8 63	22.7 64	50 62	41.1	5.2	40.0	16 64	24.6	3.8	24.0	OCT 1
OCT 11	29.5	4.4	30.0	35.4 59	19.9 69	48 59	40.2	4.9	40.0	15 69	21.2	4.0	22.0	OCT 11
MONTH														MONTH
JUN	40.9	2.3	40.0	45.3 58	37.2 62	62 54	53.0	5.0	52.0	27 64	30.8	2.3	31.0	JUN
JUL	44.2	1.9	43.0	47.4 55	40.8 63	69 64	57.9	5.0	57.0	29 62	33.9	2.0	34.0	JUL
AUG	42.5	2.3	42.0	46.8 65	38.3 64	65 65	55.8	4.4	56.0	26 65	32.1	2.9	31.5	AUG
SEP	36.4	3.4	36.0	41.9 59	29.9 64	59 67	49.9	4.9	51.0	16 70	24.6	4.1	26.0	SEP

Table 11.—Daily maximum and minimum temperatures (°F): mean, median, and extreme (based on 24 hours ending at 1600 m.s.t.)

M A X I M U M   T E M P E R A T U R E

PERCENTAGE FREQUENCY DISTRIBUTION OF DAILY VALUES
-GIVEN TO TENTHS PERCENT, DECIMAL POINT OMITTED

STATION NUMBER 241507   NINEMILE RS   1954-1970

PRD. BEGINS	BELOW 0	0 TO 4	5 TO 9	10 TO 14	15 TO 19	20 TO 24	25 TO 29	30 TO 34	35 TO 39	40 TO 44	45 TO 49	50 TO 54	55 TO 59	60 TO 64	65 TO 69	70 TO 74	75 TO 79	80 TO 84	85 TO 89	90 TO 94	95 TO 99	100 AND ABOVE	PRO. BEGINS
MAY 11											32	90	97	148	174	200	129	65	52		13		MAY 11
MAY 21											23	11	80	189	154	143	189	131	57	23			MAY 21
JUN 1												6	35	88	153	241	200	153	88	35			JUN 1
JUN 11												6	47	118	142	112	207	172	124	47	18	6	JUN 11
JUN 21												12	24	82	100	112	153	188	188	118	24		JUN 21
JUL 1														29	35	100	118	176	253	224	65		JUL 1
JUL 11														6		47	100	153	235	265	147	47	JUL 11
JUL 21																27	27	124	269	382	140	32	JUL 21
AUG 1															12	18	65	135	247	371	118	35	AUG 1
AUG 11													12	12	18	29	35	124	282	324	124	41	AUG 11
AUG 21														41	72	108	169	159	190	123	123	15	AUG 21
SEP 1												11	11	67	83	133	161	172	172	128	50	11	SEP 1
SEP 11										17	6	23	85	113	96	124	141	203	147	40	6		SEP 11
SEP 21										6	12	106	71	135	147	124	147	112	82	59			SEP 21
OCT 1										29	80	101	101	210	159	101	145	58	7	7			OCT 1
OCT 11										40	97	202	218	129	153	129	32						OCT 11
MONTH																							MONTH
JUN												8	35	96	132	155	187	171	134	67	14	2	JUN
JUL														11	11	57	80	150	253	293	118	27	JUL
AUG													4	19	36	54	93	140	237	265	121	30	AUG
SEP										8	6	46	55	104	108	127	150	163	135	76	19	4	SEP

M I N I M U M   T E M P E R A T U R E

PERCENTAGE FREQUENCY DISTRIBUTION OF DAILY VALUES
-GIVEN TO TENTHS PERCENT, DECIMAL POINT OMITTED

STATION NUMBER 241507   NINEMILE RS   1954-1970

PRD. BEGINS	BELOW 0	0 TO 4	5 TO 9	10 TO 14	15 TO 19	20 TO 24	25 TO 29	30 TO 34	35 TO 39	40 TO 44	45 TO 49	50 TO 54	55 TO 59	60 TO 64	65 TO 69	70 TO 74	75 TO 79	80 TO 84	85 TO 89	90 TO 94	95 TO 99	100 AND ABOVE	PRO. BEGINS
MAY 11						49	140	343	245	154	56		14										MAY 11
MAY 21						27	93	273	240	273	67	27											MAY 21
JUN 1							13	161	302	275	174	74											JUN 1
JUN 11							7	110	241	317	269	48		7									JUN 11
JUN 21							27	141	227	351	169	52	13	19									JUN 21
JUL 1							6	37	239	325	258	98	18	12	6								JUL 1
JUL 11								24	136	254	367	160	36	18	6								JUL 11
JUL 21								43	243	330	200	97	70	11	5								JUL 21
AUG 1								31	231	375	244	75	44										AUG 1
AUG 11								71	276	335	206	65	47										AUG 11
AUG 21							16	135	238	285	192	98	16	10	10								AUG 21
SEP 1						18	119	205	239	216	114	85	6										SEP 1
SEP 11					18	48	132	246	180	204	108	60	6										SEP 11
SEP 21					20	39	171	257	289	151	72												SEP 21
OCT 1					8	152	256	304	160	64	48	8											OCT 1
OCT 11					103	190	224	250	121	95	17												OCT 11
MONTH																							MONTH
JUN							18	136	257	315	203	58	4	9									JUN
JUL							2	35	207	304	273	118	43	14	6								JUL
AUG							6	82	249	329	212	80	34	4	4								AUG
SEP					12	34	139	234	234	192	99	50	4										SEP

Table 12.—Daily maximum and minimum temperatures (°F): frequency distributions (based on 24 hours ending at 1600 m.s.t.)

WIND SPEED - DIRECTION
PERCENTAGE FREQUENCY OF OCCURRENCE BY DIRECTION FOR SELECTED SPEED INCREMENTS
-GIVEN TO TENTHS PERCENT, DECIMAL POINT OMITTED

STATION NUMBER 241510 WEST FORK BUTTE 1953-1963

MONTH JUL — WIND SPEED, MPH

DIR.	0-3 N.	0-3 PCT	4-7 N.	4-7 PCT	8-12 N.	8-12 PCT	13-18 N.	13-18 PCT	19-24 N.	19-24 PCT	≥25 N.	≥25 PCT	TOTAL N.	TOTAL PCT	AVG SPEED
NE	1	4	11	43	1	4							13	51	5.23
E	4	16	7	28	6	23	1	4					18	71	6.56
SE			2	8	2	8							4	15	7.50
S					3	12	1	4					4	16	10.25
SW			9	35	18	71	13	51	4	16			44	173	11.39
W	1	4	21	83	68	268	44	173	11	43	2	8	147	579	12.04
NW	2	8	5	20	6	23	5	20	1	4			19	74	9.16
N	2	8			1	4							3	12	4.67
CLM	2	8											2	8	0.00
TOT	12	47	55	217	105	413	64	252	16	63	2	8	254		10.69

MONTH AUG — WIND SPEED, MPH

DIR.	0-3 N.	0-3 PCT	4-7 N.	4-7 PCT	8-12 N.	8-12 PCT	13-18 N.	13-18 PCT	19-24 N.	19-24 PCT	≥25 N.	≥25 PCT	TOTAL N.	TOTAL PCT	AVG SPEED
NE	1	4	2	7	2	7							5	18	6.20
E	1	4	9	33	7	25							17	62	7.06
SE			6	22	3	11	2	7					11	40	8.91
S					1	4	2	7	1	4			4	14	14.75
SW			2	7	18	65	14	51	2	7			35	130	12.25
W	7	25	31	112	75	272	53	192	5	18	2	7	173	627	10.90
NW	2	7	8	29	9	32	3	11					22	80	8.27
N	1	4	2	7									3	11	3.33
CLM	5	18											5	18	0.00
TOT	17	62	60	217	115	417	74	268	8	29	2	7	276		10.30

STATION NUMBER 241305 WILLIAMS PEAK 1954-1970

MONTH JUL — WIND SPEED, MPH

DIR.	0-3 N.	0-3 PCT	4-7 N.	4-7 PCT	8-12 N.	8-12 PCT	13-18 N.	13-18 PCT	19-24 N.	19-24 PCT	≥25 N.	≥25 PCT	TOTAL N.	TOTAL PCT	AVG SPEED
NE	5	13	2	5			1	3					8	20	4.13
E	2	5	2	5			1	3					5	13	6.40
SE	4	10	4	10	1	3							9	23	4.33
S	8	20	36	91	33	84	15	38	4	10			96	244	8.92
SW	20	51	46	117	50	127	14	36	1	3			131	333	7.70
W	14	36	35	89	20	51	2	5					71	181	6.13
NW	5	13	23	59	14	36	1	3	1	3			44	112	6.57
N	6	15	3	8	2	5							11	28	4.18
CLM	18	46											18	46	0.00
TOT	82	209	151	384	120	305	34	87	6	15			393		6.97

MONTH AUG — WIND SPEED, MPH

DIR.	0-3 N.	0-3 PCT	4-7 N.	4-7 PCT	8-12 N.	8-12 PCT	13-18 N.	13-18 PCT	19-24 N.	19-24 PCT	≥25 N.	≥25 PCT	TOTAL N.	TOTAL PCT	AVG SPEED
NE	9	20	8	17	2	4							19	41	3.95
E	6	13	3	7									9	20	3.67
SE	1	2	3	7	3	7	1	2					8	17	7.38
S	13	28	34	74	35	76	16	35					98	214	8.22
SW	19	41	46	100	56	122	12	26	2	4			135	295	7.87
W	14	31	41	90	35	76	14	31	4	9			108	236	8.13
NW	6	13	10	22	6	13	9	20	1	2			32	70	8.75
N	3	7	3	7	1	2	1	2					8	17	6.13
CLM	41	90											41	90	0.00
TOT	112	245	148	323	138	301	53	116	7	15			458		7.08

Table 13.—Windspeed (mi/h) at 1600 m.s.t.: average and frequency distribution by direction

TEMPERATURE - RELATIVE HUMIDITY - WINDSPEED
PERCENTAGE FREQUENCY OF OCCURRENCE FOR SELECTED COMBINATIONS
-GIVEN TO TENTHS PERCENT, DECIMAL POINT OMITTED

STATION NUMBER 241507 NINEMILE RS 1954-1970

MONTH JUL

WIND SPEED 0-4 MPH — RELATIVE HUMIDITY

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
≥100										
95-99		8		2						
90-94	2	21	19	13						
85-89		32	40	11		2				
80-84		9	38	21	6	4				
75-79			8	11	4	2	2			
70-74				9	5	9	2	2		
65-69					4	2		4	2	
60-64					2	2	4	4		2
55-59						2	2	4	4	
50-54										
45-49										
40-44										
35-39										
30-34										
<30										
TOTAL	2	70	104	68	21	23	9	13	6	2
NUMBER	1	37	55	36	11	12	5	7	3	1

WIND SPEED 5-9 MPH — RELATIVE HUMIDITY

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
≥100										
95-99		13	4							
90-94		42	23	2						
85-89	2	27	53	15	4					
80-84	2	19	40	21	4	2				
75-79		2	19	11	11	2				
70-74			9	15	13	2	2	2		
65-69			2	8	2	6	4	2		
60-64					4	4		6	4	
55-59									2	
50-54										
45-49										
40-44										
35-39										
30-34										
<30										
TOTAL	4	102	150	72	38	15	6	9	6	
NUMBER	2	54	79	38	20	8	3	5	3	0

WIND SPEED 10-14 MPH — RELATIVE HUMIDITY

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
≥100		2								
95-99	2	2	2							
90-94		25	4	2						
85-89	2	46	13	4	2					
80-84	2	15	17	6	2	2				
75-79		2	13	6	9	2				
70-74		4	6	8	8	4				
65-69		2		9	2					
60-64						2		2		
55-59					2		2		4	
50-54										
45-49										
40-44										
35-39										
30-34										
<30										
TOTAL	6	97	55	34	25	9	2	2	4	
NUMBER	3	51	29	18	13	5	1	1	2	0

WIND SPEED 15-19 MPH

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
≥100										
95-99										
90-94		6								
85-89		13	6							
80-84		4								
75-79		4	2							
70-74				2	2					
65-69										
60-64										
55-59						2				
50-54										
45-49										
40-44										
35-39										
30-34										
<30										
TOTAL		27	8	2	2	2				
NUMBER	0	14	4	1	1	1	0	0	0	0

WIND SPEED GREATER/EQUAL 20 MPH

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
≥100										
95-99										
90-94		4								
85-89										
80-84										
75-79		2								
70-74										
65-69										
60-64										
55-59										
50-54										
45-49										
40-44										
35-39										
30-34										
<30										
TOTAL		6								
NUMBER	0	3	0	0	0	0	0	0	0	0

TEMP. DEG F	TOTAL	NUMBER
≥100	2	1
95-99	32	17
90-94	161	85
85-89	271	143
80-84	213	112
75-79	112	59
70-74	104	55
65-69	47	25
60-64	34	18
55-59	23	12
50-54		0
45-49		0
40-44		0
35-39		0
30-34		0
<30		0
TOTAL	1000	
NUMBER		527

Table 14.—Dry bulb temperature (°F), relative humidity (percent), and windspeed (mi/h) combinations at 1600 m.s.t.: frequency distributions

T E M P E R A T U R E - R E L A T I V E H U M I D I T Y - W I N D S P E E D
PERCENTAGE FREQUENCY OF OCCURRENCE FOR SELECTED COMBINATIONS
-GIVEN TO TENTHS PERCENT. DECIMAL POINT OMITTED

STATION NUMBER 241510 WEST FORK BUTTE 1953-1963

MONTH JUL

WIND SPEED 0-4 MPH — RELATIVE HUMIDITY

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
>100										
95-99										
90-94										
85-89										
80-84			4	12		4				
75-79			23	8						
70-74				12	8					
65-69			8	4	4		4			
60-64						4		4		
55-59									4	
50-54										
45-49										
40-44										
35-39										
30-34										
<30										
TOTAL			35	35	12	8	4	4	4	
NUMBER	0	0	9	9	3	2	1	1	1	0

WIND SPEED 5-9 MPH — RELATIVE HUMIDITY

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
>100										
95-99										
90-94			4							
85-89		16	4	12						
80-84	4	20	16	20						
75-79		12	39	16	4					
70-74			16	35	35	8	4			
65-69				20	16	4	4			
60-64					12	12	4	4		4
55-59				4				4		
50-54			4					4		
45-49										4
40-44										
35-39										
30-34										
<30										
TOTAL	4	47	82	105	66	23	12	12		8
NUMBER	1	12	21	27	17	6	3	3	0	2

WIND SPEED 10-14 MPH — RELATIVE HUMIDITY

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
>100										
95-99										
90-94			4							
85-89										
80-84			31	12						
75-79		20	39	27	12					
70-74		8	16	27	12	8				
65-69			8	8	12	4				
60-64			4	4	12	12	8	4		
55-59					8	8	4	4		
50-54									4	4
45-49									8	
40-44										
35-39										
30-34										
<30										
TOTAL		27	102	78	55	31	12	8	12	4
NUMBER	0	7	26	20	14	8	3	2	3	1

WIND SPEED 15-19 MPH

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
>100										
95-99										
90-94										
85-89										
80-84			12							
75-79			51	16	8					
70-74		4	16	23						
65-69				8	4					
60-64					8	4				
55-59				4	4	4	4			
50-54										
45-49										
40-44										
35-39										
30-34										
<30										
TOTAL		4	78	51	23	8	4			
NUMBER	0	1	20	13	5	2	1	0	0	0

WIND SPEED GREATER/EQUAL 20 MPH

TEMP. DEG F	1 TO 10	11 TO 20	21 TO 30	31 TO 40	41 TO 50	51 TO 60	61 TO 70	71 TO 80	81 TO 90	91 TO 100
>100										
95-99										
90-94										
85-89										
80-84										
75-79		4								
70-74		4	12							
65-69				4						
60-64				4		8				
55-59										
50-54										
45-49							4			
40-44										
35-39										4
30-34										
<30										
TOTAL		8	12	8		8	4			4
NUMBER	0	2	3	2	0	2	1	0	0	1

TEMP. DEG F	TOTAL	NUMBER
>100		0
95-99		0
90-94	8	2
85-89	31	8
80-84	133	34
75-79	277	71
70-74	246	63
65-69	109	28
60-64	109	28
55-59	51	13
50-54	16	4
45-49	16	4
40-44		0
35-39	4	1
30-34		0
<30		0
TOTAL	1000	
NUMBER		256

Table 14.—(con.)

Finklin, Arnold I. Summarizing weather and climatic data—a guide for wildland managers. Gen. Tech. Rep. INT-148. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 43 p.

Presents and illustrates methods the wildland manager can use to summarize available fire-weather and climatic data. The data analysis is in the form of frequency distributions as well as average values; these can be obtained largely through available computer programs. The scope also provides for general needs of forestry research.

KEYWORDS: climate, fire-weather, climatic data analysis, fire-management planning

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

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